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TREATISE ON POWDER METALLURGY

VOLUME III

Classified and Annotated Bibliography

TREATISE ON POWDER METALLURGY *in three volumes*

by Claus G. Goetzel

Volume I:
Technology of Metal Powders and Their Products

Volume II:
Applied and Physical Powder Metallurgy
Part 1. Applied Powder Metallurgy—Industrial Materials and Products
Part 2. Physical Powder Metallurgy—Practical Evaluations and Theoretical Analyses of the Materials, Products, and Processes

Volume III:
Classified and Annotated Bibliography
Part 1. Literature
Part 2. Patents

TREATISE ON POWDER METALLURGY

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Volume III

Classified and Annotated Bibliography

1952

INTERSCIENCE PUBLISHERS, INC., NEW YORK
INTERSCIENCE PUBLISHERS LTD., LONDON

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INTERSCIENCE PUBLISHERS, INC.
250 Fifth Avenue, New York 1, N. Y.

For Great Britain and Northern Ireland:
INTERSCIENCE PUBLISHERS, LTD.
2a Southampton Row, London

PRINTED IN U.S.A.

PREFACE

Powder metallurgy has grown into a formidable branch of metallurgical engineering. Common principles of its diversified technique unite such heterogeneous applications as the incandescent lamp filament, the porous metal bearing, the permanent magnet, the hard metal cutting tool. To these must be added the mass production of small metal parts, a competitive process that emerged a few years before the recent war. Taking place concurrently with this spectacular development has been a constantly increasing number of investigations, both academic and industrial, into all aspects of metal powders and their products. And the progress of the industry as a whole is mirrored in a steady growth in the volume of patented inventions in individual fields of application.

In the past, several noteworthy attempts have been made to list the references or patents pertaining to the subject. Among those who have made major contributions in this respect are:

Miss Norma B. McDonald, who under the auspices of the Library of Congress published in this country in 1943 the first combined literature and patent reference collection, *Powdered Metals—A Bibliography*, comprising over 700 literature references and nearly 600 patents.

Dr. Franz Skaupy, who in the 3rd edition of his book "Metallkeramik" in 1943 gave an impressive listing and description of some 250 patents (mostly German) and augmented the listing further in the 4th edition of 1950.

Dr. J. Reitstötter, who in 1943 (*Kolloid Z., 103*, No. 2, 182-184) presented a review of mainly German patents covering various processes for the production of metal powders.

Mr. B. Waeser, who in 1944 in two articles (*Kolloid Z., 106*, No. 3, 229-240; *109*, No. 1, 52-60) presented a comprehensive review of the important patents in the field of hard metals and powder metallurgy in general.

Mr. J. Rossman, who in 1944 (*Trans. Electrochem. Soc., 85*, 169-173) expanded his earlier review of U. S. patents on metal powder production by electrolysis (*Metal Ind., N. Y., 30*, 321-322, 396-397, 436, 468-469, 1932).

Mr. P. Grodzinski, who through the Industrial Diamond Information Bureau, London, in April, 1945, and August, 1948, published some 700 classified and annotated references in *Diamond Tool Patents I and II.*

Mr. Raymond E. Jaeger, and Miss Rolla E. Pollard, who under the auspices of the U. S. Bureau of Standards published in 1947 *United States Patents on Powder Metallurgy*, which is to date the most complete classified and annotated collection of domestic patent references, comprising some 2250 items.

Dr. H. H. Hausner, who in 1947, in his book *Powder Metallurgy*, presented a listing of more than 1000 literature references.

Dr. G. H. S. Price, who also in 1947, in his bibliography on powder metallurgy (*Metal Treatment, 14*, No. 49, 42-65, No. 50, 113-130), published a collection of nearly 1000 literature references in chronological order.

Mr. R. A. Hetzig, who in 1949 in *Overall Report No. 20* of the British Intelligence Objective Subcommittee gave the first comprehensive summary of the multitude of references to reports by Allied Field Investigators on their visits to German powder metallurgy installations immediately after the last war.

While the material contained in these principal reference collections had already become quite voluminous, it was felt that their combination and incorporation into a comprehensive presentation with exclusion of unnecessary duplication would be an improvement. Thus, it became one of the prime purposes of this final volume of *Treatise on Powder Metallurgy* to knit together the abundant references already published in the form of independent surveys. My own collection, started in 1936 in the form of a cross index on cards and arranged according to subject as well as authors or inventors, had expanded to huge proportions over the years, and I was tempted to draw on it in filling the gaps left by other collections, and to work the whole into a clearly annotated and logically classified literature and patent bibliography.

Thus, almost 12,000 reference citations were assembled for this volume by the beginning of 1950. While this bibliography does not claim to be a complete one, it is, to my knowledge, the most comprehensive work of its kind yet published on the subject. It is my hope that Volume III of *Treatise on Powder Metallurgy* will prove of help and much usefulness for the researcher and technical worker, the industrialist and plant engineer, the inventor and patent attorney, the librarian, and general student of the art.

Any presentation of a comprehensive literature and patent bibliography, even in a less heterogeneous field than powder metallurgy, would be difcult to limit strictly to the references directly related to the subject. The term "powder metallurgy," as defined in Volume I, is usually applied to the "art and science of manufacturing useful articles from metal powders and of producing those powders." This excludes some of the most important industrial uses of metal powders, such as paints and pigments, metallic coatings, and catalysts. But the methods of producing, handling, and testing of metal powders are essentially the same, whether the powder is used as such or processed further into articles by pressing and sintering. For this reason, some of the fringe applications are included in Volume III of *Treatise on Powder Metallurgy*. In addition to the subjects of pigments, coatings, and catalysts, there are included in the bibliography metal powder applications in metallurgical processes and their production as a step in the refining or processing of ores. Also included are specific machinery used in powder metallurgy, such as grinding mills, presses, furnaces, as well as devices used in testing and classifying metal powders,

such as sieving machines, separators, flowmeters. Naturally, in these border regions, it becomes exceedingly difficult to draw a line and to decide which references to include and which to omit, as the connection with metallic powders remains the only guide. Thus, it became unavoidable that the fringe regions remained incomplete. The reader is advised to consult the specialized literature in all these cases.

Both parts of Volume III contain references up to January 1, 1950. Exceptions are a few literature items published in 1950, which are new book editions or continuations of parts published previously. Also included in the bibliography are the twenty-odd papers presented at the *Symposium on the Physics of Powder Metallurgy* sponsored by Sylvania Electric Products Company in August, 1949, but only published in book form in January, 1951.

In the patent reference collection, the year given is that of the *issue* of the patent. This was decided to be preferable over the European practice of giving the year of *filing* of the patent application, as it facilitates patent search in the library, and probably serves the greatest number of readers. The citation of the filing date was omitted for space considerations, since it serves merely to indicate the priority of the invention, which is probably of interest only to a limited circle of readers who most likely would consult the original patent in any event.

In the American patent citations, the inventor is given, and where possible the assignee. In all other countries, the companies owning the patent are named where published at the head of the patent. The addition of the name of the inventor could not be carried through uniformly, as many international patents, especially during the war years, could only be located in abstract form, and as such failed to give the individual inventor.

Finally, the reader should be acquainted with the meaning of several abbreviations of repeatedly cited references relative to reports by Allied Government Agencies and Field Investigators, necessitated by space-saving considerations:

A. E. C. U.	Atomic Energy Commission Unclassified (American)
B. I. O. S.	British Intelligence Objective Subcommittee (British)
B. O. T.	Board of Trade (British)
C. I. O. S.	Combined Intelligence Objectives Subcommittee – (American and British)
F. D.	Foreign Documents (British)
F. I. A. T.	Field Intelligence Agency Technical (American)
H. E. C.	Halstead Exploitation Centre (British)
J. I. O. A.	Joint Intelligence Objectives Agency (American)

N. E. P. A.	Nuclear Energy for the Propulsion of Aircraft (American)
P. B.	Publication Board (American)
T. I. D. U.	Technical Information and Documents Unit (American)

The reader especially interested in the Russian and Scandinavian references might find it helpful to know that a number of them have been translated into English by Henry Brutcher Technical Translation Service, Altadena, California.

ACKNOWLEDGMENTS

The preparation of Volume III of *Treatise on Powder Metallurgy* could not be a one man job. The compilation of a truly comprehensive reference collection, even in as specialized a field as powder metallurgy, became a formidable task indeed. It required well over a dozen years of tedious and sometimes painstaking effort and long hours of work in libraries and archives.

A bibliography is a symbol of a live and constantly growing organism, in a way more closely allied with the subject it kaleidoscopically reflects than any text can ever hope to be. It is most important that at all times it stays abreast of the developments in the art. It requires an equal effort of classifying, cross-checking, and editing.

I have had invaluable assistance from relatives, friends, and colleagues, without whose support the bibliography in its present form would have been an impossibility. My gratitude to all who contributed so generously by giving their valuable time and effort, or financial support, is boundless. It is they who deserve whatever credit is due for this work.

The roster of individuals and organizations that have so kindly collaborated with me is a long one, and points to many locations in this country and abroad. It would lead too far afield to cite all the libraries and institutions who have cooperated. But some of the individuals deserve special citation and my expression of sincere appreciation for their cooperation and personal efforts:

In Germany, I have had the help of Dr. Franz Skaupy, formerly of the Osram Gesellschaft, Berlin, and Drs. Carl Hundhausen and J. Hinnüber of the Widia-Fabrik, Essen, in establishing data on some of the rarer references.

In Austria, I have had wonderful support from Mr. Fritz Benesovsky and Dr. Richard Kieffer of The Metallwerk Plansee, Reutte. Without their major contributions in the form of reference listings and collections and library researches, the bibliography would have been lacking in many of the German, Austrian, Italian, and Czechoslovakian patent references, and also in many German literature items, especially those published during the recent war.

In England, I was fortunate to secure the aid of my good friend and colleague, Mr. Reginald A. Hetzig, editor of the *Metal Powder Report* in London. Without his library researches, the presentation of the many Allied Field Investigation Documents and Reports would have remained far less comprehensive.

In this country, I was materially helped by Mr. Henry Brutcher, Altadena, California, and Mr. Eugene Polushkin of New York, who translated and abstracted innumerable patent and literature references from Russian, Czechoslovakian, Swedish, Norwegian, Danish, Dutch, and Italian sources, thus permitting intelligent annotations in this presentation.

For his relentless efforts and sacrificial help in the multitude of technical details connected with library searches, cross-indexing and advance classification, my most sincere gratitude is expressed to my dear friend, Mr. Hans Eyck. Without his intensive collaboration during the last five years, the bibliography would have remained sketchy and fragmentary.

Likewise, my sincere thanks and appreciation go to Mrs. Dorothy Trauberman, who during the closing phases of the work made major contributions by cross-checking and correction of many references, and by general editorial work.

I am also most indebted to my friend and benefactor, Mr. Erwin Loewy, who so generously has supported the compilation of this bibliography in its later stages.

Last, my everlasting gratitude goes once more to my family for their forbearance and sacrifices, and to Mrs. Lilo K. Goetzel, my dear wife, in particular. Not only was her material aid in establishing and developing this annotated and classified bibliography of decisive value, but her never-ending encouragement and moral support has been a vital element in inducing me to write and complete *Treatise on Powder Metallurgy*.

C. G. G.

New York, December, 1951.

HOW TO USE THIS BIBLIOGRAPHY

This volume has been divided into two parts. The first contains a classified and annotated literature collection, the second a classified and annotated patent bibliography. The organization of both parts was logically carried out in close conformance with the text in Volumes I and II. Thus, the reader of the first two volumes, interested in a quick cross reference or a more comprehensive check of the available sources pertaining to the particular subject matter under discussion in the text, will be able to locate the pertinent references without difficulty or loss of time. The annotations in Volume III should, in general, prove adequate to indicate to him which of the references cited will be of sufficient interest to him for further library study of the original article or patent.

While it was found possible to organize the patent references strictly according to the classification adopted, this was not so in the case of some literature references covering more than one specific topic. Thus, it was found necessary in about one tenth of the literature items to make two or more citations in different sections. No duplicate references are cited in the patent survey.

In searching for a specific reference complex, the reader is advised to use the Table of Contents or the Subject Index as a guide for his first selection of the particular class or section. But he will do well to look also directly under the main section heading, where items that cannot clearly be subclassified or that cover more than one subclass are found.

For example, an article on cemented carbide compositions and applications is cited immediately after the main heading "IV.2. Hard Metal Compositions and Products."

The dual nature of many references justifies carrying them under occasionally quite different headings, depending upon either the emphasis given by the original writer or inventor, or the emphasis given by this author. Thus, it is unavoidable that, especially in the literature section, the item may often not be found in the section or "thereabouts", where the reader vaguely remembers having seen it before, or where he is "sure" it should be. In order to save prolonged search, he is advised to consider immediately any additional sections which have a direct or even more remote bearing on the reference in question.

For example, literature on sponge iron should be looked up under "II.2. Methods and Equipment for Manufacturing Specific Compositions of Powders (A. Metal Powders)," and also under "II.1. General Methods and Equipment for Powder Manufacturing (C. Chemical Processes)," or under "IV. 10. Miscellaneous Applications for Metal Powders (C. Applications for Metallurgical Industries)."

Literature on Permalloy powder could be found under "II.2. Methods and Equipment for Manufacturing Specific Compositions of Powders (B. Alloy Powders)" and also under "IV.4. Magnetic Materials and Products (C. High Frequency Cores)."

Literature on ore dressing is presented under "II.1. General Methods and Equipment for Powder Manufacturing (C. Chemical Processes)," but also under the same main heading in the section on "A. Mechanical Processes" or under the various subdivisions of "IV. Powder Metallurgy Products; Their Compositions, Properties, and Manufacture," *e.g.*, "1. Refractory Metals and Alloys," "5. Ferrous Materials and Products" or "6. Nonferrous Materials and Products."

Literature on bearings should be looked up under "IV.7. Porous Products (A. Bearings and Bushings)," and also under "IV.6. Nonferrous Materials and Products (A. Copper and Copper Alloys)" and under "IV.10. Miscellaneous Applications for Metal Powders (A. Sintered Products)." The latter section should also be consulted in a search for references on steel-backed bearings and other composites, except friction elements, which are listed under "IV.8. Friction Products."

Literature on the production of rare metals can be found either under "II.2.A. Metal Powders" or under "IV.1. Refractory Metals and Alloys (D. Rare Metals)," depending on whether the production is in form of powders or as deposits, flakes or bulk metal.

As a further example, the description of pressing agents, *e.g.*, glycerine, in the molding of cemented carbide powders may be found under "III. Powder Processing Methods and Equipment (1. Powder Conditioning Treatment)," or under the same heading in the section on "2.A. Static Pressing," but should also be looked up under "IV.2. Hard Metal Compositions (A. Cemented Carbides)."

As an example of the dependency of the classification on the emphasis in the reference, items on the *determination* of powder particle size would be carried under "II.4. Testing and Control Methods and Equipment (A. Particle Characteristics)," while the *effect* of powder particle size on the determination of the void contents in powder packings should be looked up under the same heading, in the section on "B. Physical Properties of Powders and Particles."

In the same sense, references to the oxidation of metal powders while being examined in the electron microscope should first be looked up under "II.4. Testing and Control Methods and Equipment (A. Particle Characteristics)" and only in an additional search under "II.3. Properties and Behavior of Metals, Alloys and Compounds in Powder Form (B. Chemical Properties)."

As an additional aid in connection with the Patent Survey, a patent cross index has been provided which locates by item number in Volume III all patents mentioned in Volumes I and II (see page 809).

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Part 1
LITERATURE SURVEY

I. Powder Metallurgy - General

1. HISTORICAL ACCOUNTS AND SURVEYS, LITERATURE AND PATENT COLLECTIONS, BIBLIOGRAPHIES

(1) The Production of Flake Metal in the Past and at Present. W. Theobald, *Glasers Ann.*, Nos. 833, 842-845 (1912). A historical review of the various methods and apparatus for the mechanical pulverization.

(2) Production of Bronze Colors in the Past and Present. W. Theobald, *Dinglers Polytech. J., 328,* 163-66, 182-86, 214-17, 262-65, 278-83 (1913). A good history of metal pigment powders.

(3) The Story of Nickel. W. H. Baldwin, *J. Chem. Ed., 8,* 1749-61, 1954-68, 2325-40 (1931). A historical review which includes the production of nickel powder and granules by the carbonyl process.

(4) Powdered Metals by Electrolytic Methods. J. Rossman, *Metal Ind. (N.Y.), 30,* 321-2, 396-7, 436, 468-9 (1932). A review of patents is presented.

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(7) Sintered Metal Powder. *Alloy Metal Rev., 1,* No. 1, 1-2 (1936). Short historical review.

(8) The Manifold Uses of Aluminum Powder. E. Herrmann, *Aluminium, 18,* No. 8, 376-81 (1936). Patent literature review.

(9) Sintered Metal Powders. *Chem. Age (London), 36,* Metallurgical Section, Suppl. 4 (1937). Short historical review.

(10) Metallurgy and Technology of Gold and Platinum among the Pre-Columbian Indians. P. Bergsøe, *Danmarks Naturridens Kabelige Samfurd,* F. C. Reynolds, Copenhagen, 1937, 52 pp. *C. A., 31,* 6097. Powder metallurgical principles are evidently of most ancient origin. Compacting and sintering was practiced at that time.

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(12) The Metal Carbonyls. W.E. Trout, Jr., *J. Chem. Ed., 14,* 453-459 (1937). A historical summary is given with some attention being paid to the life of Ludwig Mond. Lengthy discussions are included on Ni and Fe carbonyls. Comprehensive bibliography.

(13) The Field of Powder Metallurgy – and Bibliography. *Metals Disintegrating Co.*, Elizabeth, N.J., 1939, 48 pp. Leaflet containing a collection of references on powders and powder metallurgy.

(14) Artificial Porous Metal Bodies. W. Machu, *Kolloid-Z., 88*, 251-6 (1939). A review of patents of bearings, catalysts, filters and infiltration is presented.

(15) Sintered High-Melting Hard Substances. W. Machu, *Kolloid-Z., 88*, 373-84; *89*, 92-104 (1939). A review of patents, pertaining to cemented carbides and their products.

(16) Powder Metallurgy – A Review of Its Literature. C.B. Carpenter, *Colorado School of Mines Quarterly, 35*, No. 4, Oct. 1940, 40 pp. Colorado School of Mines monograph, giving a broad review of developments in form of an annotated literature survey.

(17) Powder Metallurgy – As It Was in 1915, As It Is in 1940. Z. Jeffries, *Metal Progress, 37*, No. 3, 314 (1940). Historical review of developments in powder metallurgy over the last quarter century.

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(21) Powder Metallurgy – A Review of Its Literature. C. B. Carpenter, *Colorado School of Mines Quarterly, 36*, No. 4, Oct. 1941, 55 pp. Colorado School of Mines monograph. Field is completely covered in the revised edition.

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(23) On the Historical Development of Sintered Hard Metals. F. Skaupy, *Metallwirtschaft, 20*, No. 21, 537-539 (1941). Review of the pertinent patent literature.

(24) Patent Survey on Powder Metallurgy. A.W. Deller, *Powder Metallurgy, Am. Soc. Metals, Cleveland, 1942, Chapt. 51*, pp. 551-603. Patent literature, definitions, history, principles, products, testing are presented.

(25) Iron Making. R. Durrer, *Die Metallurgie des Eisens*, Verlag Chemie, Berlin, 1942. On pp. 6-7, the prehistoric practice of iron making by using powder or sponge is described.

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(33) Recent Development Trends in Powder Metallurgy. R. Kieffer and W. Hotop, *Metallwirtschaft, 23,* No. 40/43, 361-66 (1944). A review of the pertinent literature is given.

(34) Powder Dispersoids. K. A. G. Meyer, *Kolloid-Z., 106,* 214-18 (1944). Literature abstracts of work during the period of 1939-1943.

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(51) Bibliography on Powder Metallurgy with Emphasis on Porous Metals. F. E. Croxton, *U. S. Atomic Energy Comm. 2763,* 26 pp. (1948). 233 references are given.

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(53) Powder Metallurgy. W. D. Jones, *Metal Ind. (London), 72,* No. 2, 23-24 (1948). Review of progress in 1947; reference collection on manufacture, testing, pressing, sintering, and products.

(54) New Trends in Powder Metallurgy. Chem. Age (London), 61, 631-33 (1949). Reviews Swiss developments in ferrous powder metallurgy on the basis of recently issued British Patent Applications by D. Primavesi: No. 32,066/48 on electrolytic iron powder production; No. 32,363/48 on iron powder by conversion of oxides to chlorides; No. 32,717/48 on sintered cupric steels. Also reviews Czechoslovak developments in the cemented carbide field as disclosed in the British Patent Applications by the Skoda Works: No. 31,804/48 on nonporous sintered hard metal; No. 32,319/48 on complex cemented carbide compositions; No. 32,713/48 on rotary drill bits, cutting tool tips, etc. made from composite structures of high-cobalt cores and low-cobalt rims.

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(57) Powder Metallurgy in Germany during 1939-1945. R. A. Hetzig, B.I.O.S. Over-all Report No. 20, 28 pp. (1949). The report summarizes the information gained by Allied teams who visited German factories. The majority of the items of this report are abstracted individually in this bibliography.

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(59) Powder Metallurgy — Review of Progress during 1949. R. A. Hetzig, *Metallurgia, 41,* No. 242, 88-90 (1949). Review of literature dealing with the following: magnetic applications; gas turbine blades; high melting point metals; hard metal; diamond tools; miscellaneous applications; theories of pressing and sintering. Bibliography.

(60) History and Theoretical Foundation of Powder Metallurgy. R. Kieffer, *Einführung in die Pulvermetallurgie,* Technische Hochschule, Graz, 1949, pp. 7-33. Historical development from Middle Ages till present time.

(61) Titanium and Zirconium in the Anglo-American Literature. O. Kubaschewski, *Z. Metallkunde, 40,* 460-62 (1949). A review with 24 references on the subject is given.

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2. GENERAL TECHNICAL REVIEWS, TEXTS, NOTES AND REPORTS

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(64) Possibilities of Powdered Metals. *Compressed Air Mag., 36,* 3659 (1931). General trends and commercial applications and possibilities. Reduction of Ni, Monel, Cr, Pt and Pd to powder form are discussed.

(65) Metals in Powdered Form Are Pressed and Sintered Into Various Shapes. C. Hardy, *Steel, 89,* No. 21, 40 (1931). Uniform particle size is obtained through a method of mesh control.

(66) *New alloys and new applications develop steadily.* Powder Metals. *Business Week,* No. 173, 7-8 (Dec. 28, 1932).

(67) Molding of Metal Powders. *Can. Machinery, 43,* No. 16, 57 (1932). Description of the molding process of W, Cr, Ni, Cu. Similar to that used in molding synthetic plastic. The formed article is sintered and the product has a structure of metal sponge.

(68) Powder Metallurgy. C. Hardy, *J. Met. Ind., 30,* 179 (1932). Preparation of solid pieces of metals and alloys by pressing and sintering.

(69) Manufacture and Use of Powdered Metals. C. Hardy, *Metal Progress, 22,* No. 1, 32-37, 80 (1932). Oilless bearings and iron cores are described.

(70) Powder Metallurgy Competes Effectively with Smelting and Machining Processes. C. Hardy, *Eng. Mining J., 134,* No. 9, 373-4 (1933). Methods of making powders; advantages over casting methods, etc.

(71) Achievements in Powder Metallurgy. *Iron Age, 134,* No. 12, 42 (1934). Interesting progress in powder metallurgy has been achieved recently. Bronze bearings are cited as one particularly interesting development.

(72) Powder Metallurgy and Its Applications. *Mining & Metallurgy, 15,* 256 (1934). Review.

(73) Progress in the Sintering of Metal Powders. W. D. Jones, *Metallurgist* (Suppl. to Engineer), *159,* No. 10, 10-13 (1935). Methods of producing metal powders, control of grain size, and sintering methods are described.

(74) Up-to-Date Alloys of Soviet Origin (in Russian). S. B. Kocharov, *Neft, 6,* No. 14, 7 (1935). *Met. Abstracts, 5,* 782 (1938). Three groups of hard alloys are described: *(1)* powdered alloys (Stalinit, Vokar, Dognat); *(2)* cast alloys (Sormite, Smena, Stellit); *(3)* pressed and sintered alloys (Probedit).

(75) Metallographic Viewpoints on Powder Metallurgy. G. Sterky, *Jernkontorets Ann., 119,* No. 7, 255-80 (1935). A review with special reference to hard metals, Tungsten, etc., is presented.

(76) Powder Metallurgy. *Automotive Inds., 75,* 787 (1936). A review of recent advances in the field is given.

(77) Powder Metallurgy – A Warning – A Promise. G. J. Comstock, *Metal Progress, 30,* No. 1, 49-50 (1936). Limitations and possibilities of powder metallurgy are presented.

(78) Powdered Metals. A. B. Everest, *Foundry Trade J., 54,* 329 (1936). A brief review is given. Tungsten instead of lead is suggested as shielding material in radium therapy.

(79) Powder Metallurgy: Notes on the New Art. C. Hardy, *Metal Progress, 29,* No. 4, 63-67 (1936). The process of preparing Mo and W by sintering ingots from powders is applied to mixtures of metallics and non-metallics and magnetic alloys.

(80) The Technique of Powder Metallurgy. C. Hardy, *Mining & Metallurgy, 17,* 145-6 (1936). Manufacture of powders, particle size, shape and grain distributions, various alloys and uses are described.

(81) Progress in Powder Metallurgy. *Metals & Alloys, 8,* No. 6, 157 (1937). An editorial review is presented.

(82) Powder Metallurgy. *Metal Treatment, 3,* No. 12, 157 (1937). Review.

(83) Powder Metallurgy Presents Broad Field for Experimental Development. *Steel, 100;* No. 13, 48-50 (1937). In an address by G. J. Comstock a general survey of the field is given, covering sintered tungsten carbides, coating steel with Ag, bimetals of Ag and Cu, particle size, and milling.

(84) Non-Ferrous Metals. *Times Trade & Eng., 40,* 17 (1937). Includes reference to recent developments in powder metallurgy.

(85) Powder Metallurgy. S. Frankel, *Metal Ind. (N. Y.), 35,* 101-102 (1937). General discussion of the subject is presented.

(86) Metal Powders as Raw Material in Industrial Serial Production. C. G. Goetzel, *Werkstattstechnik Werksleiter 31,* No. 20, 446-449 (1937). History, description of process, discussion of advantages over casting are given.

(87) Powdered Metals In Industry. A. W. Hahn, *Mining & Metallurgy, 18,* 294-95 (1937). Review of methods of preparing metal powders and their uses is presented.

(88) W. D. Jones, *Principles of Powder Metallurgy.* Arnold, London, 1937. First comprehensive text in English on the subject; covers topics including sintering methods, industrial applications, hard metal alloys, manufacture of powders, properties and treating. Theoretical considerations are given much space.

(89) Metallurgical Development and Progress. W. Larke, *Machinery Market, 1,* 19-20 (1937). Survey includes discussion of powder metallurgy.

(90) Powder Metallurgy. R. L. Patterson, *Metal Ind. (N. Y.), 35,* 19 (1937). General discussion of the subject is presented.

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(92) Manufacture and Use of Powdered Metals. *Metal Progress, 33,* No.3, 263 (1938). Review of several papers read at the Am. Inst. Mining Met. Engrs. symposium, in Feb. 1938, is presented.

(93) Powder Metallurgy. *Steel, 102,* No. 9, 45-46 (1938). General discussion of symposium of Am. Inst. Mining Met. Engrs., 1938, is given.

(94) Powder Metals. *Steel, 103,* No. 16, 41-42 (1938). Powder metals find new and important uses. Abstract of papers presented at Fall Meeting of Am. Soc. Mech. Eng. at Providence, R. I., Oct. 5-7, 1938.

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(96) Contributions of Metallurgy to Engineering Progress. W. R. Barclay, *Mining & Metallurgy, 19,* 397-400 (1938); *Mechanical Eng., 60,* 692 (1938). Review includes powder metallurgy.

(97) Powder Metallurgy – Its Increasing Importance to Industry. G. J. Comstock, *Mechanical Eng., 60,* 801-06 (1938). Principal commercial products from powdered metals, refractory metals, electrical contacts, electrode materials, porous bearings, hard cemented carbides are discussed.

(98) Powder Metallurgy. G. J. Comstock, *Metal Progress, 34,* No. 4, 508 (1938). General discussion of the subject is presented.

(99) New and Important Uses of Powder Metallurgy. G. J. Comstock, *Steel, 103,* No. 16, 41, 76 (1938). General survey of up-to-date developments is made.

(100) Types of Metal Powder Products – A Classification. G. J. Comstock, *Trans. Am. Inst. Mining Met. Engrs., 128,* 57-66 (1938). Advantages of metal powders for certain purposes, present state of development, and factors influencing the future, are reviewed.

(101) Powder Metallurgy. F. Fox, *Machinery (London), 53,* No. 1366, 342-344 (1938). General discussion of the subject is given.

(102) Powder Metallurgy. C. Hardy and C. W. Balke, *Metal Ind. (London), 53,* No. 4, 171-74 (1938). Definition, advantages, production, characteristics, compression and heat treatment are discussed.

(103) Metal Ceramics Molded from Powder. S. L. Hoyt, *Metal Progress, 33,* No. 2, 157-162 (1938). Review covers oilless bearings, cemented carbides, tungsten and tantalum carbides.

(104) Developments in Powder Metallurgy. W. D. Jones, *Metal Ind. (London), 52,* 75-6, 97-9, 131, 195-6 (1938). The following four subjects are treated: I. Present position; II. Casting versus powder methods; III. Shrinkage; IV. The delay in progress. Section III written in collaboration with E. J. Groom.

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(106) Powder Metallurgy Has Most Promising Future. A. J. Langhammer, *Steel, 103,* No. 15, 138, 140 (1938). General review of the field is presented.

(107) Symposium on Powder Metallurgy. F. P. Peters, *Metals & Alloys, 9,* No. 3, 69-72 (1938). Review is presented of papers given at meeting of Am. Inst. Mining Met. Engrs. on powder preparation, testing, uses, tantalum, carbides.

(108) Metallurgical Progress – Recent Developments in Powder Metallurgy. E. E. Schumacher and A. G. Souden, *Metal Ind. (London), 52,* 197-9, 243-5 (1938). Brief review.

(109) Progress in Non-Ferrous Metals and Alloys During the Past Few Years. E. E. Schumacher and A. G. Souden, *Mining & Metallurgy, 19,* 50-55 (1938). Brief description of super-purity metals and powder metallurgy products is given.

(110) Recent Developments in Powder Metallurgy. P. E. Wretblad, *Jernkontorets Ann., 122,* No. 10, 537-551 (1938). A critical review of the processes of powder metallurgy with classified treatment of the methods of preparation is presented.

(111) Powder Compacts. J. Wulff, *Technology Review, 41,* 74-6 (1938). Review of modern practice is presented.

(112) The Field of Powder Metallurgy. Metals Disintegrating Co., Elizabeth, N. J., 1939, 46 pp. Commercial applications and limitations are described. Bibliography.

(113) Powder Metallurgy. C. Claus, *Ind. Heating, 6,* 926-929, 987, 1032-34 (1939). Commercial applications, and the production of tungsten and refractory metals, porous bearings, cemented carbides, etc., are reviewed.

(114) Notes of an A. S. M. Speaker on Powder Metallurgy. G. J. Comstock, *Metal Progress, 35,* No. 4, 343-47 (1939). General history and development of the art.

(115) Metal Powders: Characteristics and Products. G. J. Comstock, *Metal Progress, 35,* No. 5, 465-67 (1939). Commercial powders and manufacturing methods are reviewed.

(116) Powder Metallurgy. E. F. Cone, *Metals & Alloys, 10,* No. 12, 390 (1939). Editorial notes on the Chicago Exposition.

(117) The Preparation of Metals in a Compact Form by Pressing and Sintering. J. D. Fast, *Philips Tech. Rev., 4,* No. 11, 309-16 (1939). The methods of powder metallurgy are discussed with special reference to W, Mo, Ta and cemented carbides.

(118) Powder Metallurgy Solves Various Problems. C. Hardy, *Eng. Mining J., 140,* 85-86 (1939). Progress during 1938 is outlined in a general review.

(119) Powder Metallurgy. C. Hardy, *Steel, 105,* No. 16, 126 (1939). Use of ferrous powders will exceed that of non-ferrous powder metallurgy; demands an entirely different purity than does melting operation. The powder must be ductile for compression, and of a grain size to adhere without a binder.

(120) Powder Metallurgy. C. Hardy and C. W. Balke, *Metals Handbook.* Am. Soc. Metals, Cleveland, 1939, pp. 104-108. Definition, advantages, production, characteristics, compression and heat treatment are covered.

(121) Progress in Powder Metallurgy. W. D. Jones, *Metal Ind. (London), 54,* 51-55 (1939). Survey of past work and future possibilities.

(122) Recent Developments in Powder Metallurgy. W. D. Jones, *Metal Treatment, 4,* No. 16, 145-149, 152 (1939). Accounts are given of the manufacture of compacts made from cast-iron powder, and of porous magnesium flares; porous bronze bearings; porous precious metal products. Alloy powders for electrical contacts.

(123) Powder Metallurgy. R. H. Leach, *Metal Progress, 36,* No. 4, 350-51 (1939). General comparison with orthodox methods is presented.

(124) U. S. Industries Using One Ton of Powdered Iron per Day. J. S. Madaras, *Steel, 105,* No. 16, 126 (1939). Pure fine metal powders are produced most readily by electrolytic methods, which add several cents to the base price of the metal. Powdered iron is produced now by carbonaceous and gaseous reduction.

(125) Possibilities of Metal Powders. C. A. Nagler, *Metals Rev., 12,* No. 9, 4 (1939). Description of talk by L. L. Wyman on cemented carbides, porous bearings, etc.

(126) Powder Metallurgy. F. P. Peters, *Metals & Alloys, 10,* No. 10, A74–A76 (1939). General technique, porous bearings, iron powder parts are described.

(127) Powder Metallurgy. P. H. Smith, *Sci. American, 160,* 80 (1939). Brief review of the subject is presented.

(128) Powder Metallurgy. A. F. Whalen, *Metals Rev., 12,* No. 9, 11 (1939). Review of lecture by R. L. Patterson on fundamentals of process.

(129) Laboratory of Powder Metallurgy at Stevens Institute of Technology. *News Ed., Am. Chem. Soc., 18,* No. 12, 548 (1940). Description and pictures of the laboratory are presented.

(130) Gear Powders. *Engineer, 169,* No. 4391, 230; *Metallwirtschaft, 19,* 958-59 (1940). Gears, brake drums, clutch rings are typical products made of metal powders. (Citation of A. D. Little Inc., *Ind. Bull.,* Jan. 1940.)

(131) Applications of Powder Metallurgy. *Glass Rev., 16,* No. 4, 54-56 (1940). A brief review is given of the production of porous bearings metals, cemented hard carbides and electrical contacts, etc., from powders.

(132) Powder Metallurgy. *Ind. Eng. Chem., News Ed., 18,* 548 (1940). Laboratory for powder metallurgy established at Stevens Institute of Technology, Hoboken, N. J.

(133) Powder Metallurgy In War and Peace. *Metal Ind. (London), 56,* No. 6, 147-148 (1940). A brief survey of some recent applications is given.

(134) Powdered Iron. *Metals & Alloys, 12,* No. 4, 594 (1940). Powdered iron pressed into shape and sintered to provide cohesion is used by the hundreds of tons, according to a paper by E. C. Smith before the American Iron and Steel Inst. on "Control of Steel Composition and the Problem it Presents."

(135) New Materials for Old. E. V. Appleton, *J. Inst. Civil Eng., 14,* No. 8, 448-68 (1940). Reference is made to the development of powder metallurgy.

(136) Developments in Diffusion, Boron Carbide, Powders, Electrodeposition. F. H. Clark, *Mining & Metallurgy, 21,* No. 397, 18-23 (1940). Developments in powder metallurgy during previous years are discussed.

(137) Powder Metallurgy. G. J. Comstock, *Baldwin Southwark, The Baldwin Locomotive Works, 4,* No. 4, 20-24 (1940). A general review includes discussion of filaments, carbides, physical characteristics.

(138) Diffusion Alloying Seen as Most Likely Metal Powder Process. G. J. Comstock, *Steel, 107,* No. 16, 190 (1940). The present conception of diffusion alloying involves primary metal powders and master alloy powders—the concentrated alloy from which diffusion is to proceed. The compacting of alloy powders is different from that of pure powders plus master alloys.

(139) Metals As Engineering Materials. C. H. Desch, *Foundry Trade J., 62,* 149-51 (1940). Last of three lectures dealing with development of powder metallurgy.

(140) Iron Powders in Europe. W.D. Jones, *Steel, 106,* No.23, 48-50 (1940). Review.

(141) Products of Powder Metallurgy in the Automotive industry. R. Kieffer, *Automobiltech. Z., 5,* No. 43, 109-112 (1940). General review of automotive applications satisfied by powder metallurgy is presented.

(142) Powder Metallurgy and Metallo-Ceramic Products. R. Kieffer, *Metall u. Erz, 37,* No. 4, 67-70; No. 5, 88-92 (1940). General review.

(143) Present Situation of Powder Metallurgy. R. Kieffer and W. Hotop, *Stahl u. Eisen, 60,* No. 24, 517-27 (1940). The up-to-date development of powder metallurgy.

(144) Materials Reorientation and Materials Saving in Instrument Making. H. Lüpfert, *Z. Ver. deut. Ing., 84,* 965-70 (1940). Resistance wires, tools, bearings, and contacts made by powder metallurgy are described.

(145) Powder Metallurgy — Recent Advances and Design Trends. F. P. Peters, *Metals & Alloys, 12,* No. 4, 471-472, 474-476, 478 (1940). A report of the Mass. Institute of Technology Summer Conference is made.

(146) Connection Between Metal Ceramics and Oxide Ceramics. F. Rollfinke, *Z. Ver. deut. Ing., 84,* No. 37, 681-89 (1940). Outline of principles and practices of powder metallurgy.

(147) Metal Ceramics. F. Rollfinke, *Z. Ver. deut. Ing., 84,* No. 49, 953-58 (1940). Powder metallurgy materials, their production and application are reviewed.

(148) Recently Developed Alloy Powders Cover Many Compositions. W. M. Saunders, Jr., *Metals Rev., 13,* No. 5, 3 (1940). Review of talk by R. L. Patterson, which covered steel powders, copper-lead, brass, and bronze powders.

(149) Processing Trends in Powder Metallurgy. P. Schwarzkopf and C. G. Goetzel, *Iron Age, 146,* No. 12, 39-45 (1940); *Engineer, 170,* No. 4425, 287-88 (1940). General discussion, uses, advantages, different metals, diagrammatic trend charts, micropictures are presented.

(150) Powdered Metal Developments. W. B. Scott, *Steel, 107,* No. 16, 164 (1940). Continuation held at a slower pace.

(151) Year's Progress in Metallurgy. R. C. Stewart, *Can. Machinery, 51,* No. 12, 141-2, 325 (1940). Review of developments includes powder metallurgy.

(152) Powder Metallurgy — Old and New Vistas. J. Wulff, *Metal Progress, 38,* No. 5, 665-668, 720 (1940). Report on the Mass. Inst. Technol. conference on powder metallurgy is made.

(153) Powder Metallurgists Debate Techniques. *Iron Age, 148,* No. 18, 29-35, 100 (1941). A review of the powder metallurgy conference at Mass. Inst. of Technol. in 1941 is given.

(154) Interesting Parts Made from Powder. *Metal Progress, 39,* No. 1, 48 (1941). Brief description of production line of Moraine Products Co.

(155) Powder Metallurgy. *Metals & Alloys, 14,* No. 1, 63 (1941). Porous metal filters, vacuum pressing, new source of carbonyl iron are discussed.

(156) Powder Metallurgy. *Mining & Metallurgy, 22,* No. 414, 297 (1941). Discussion of the subject by H. N. Davis of Stevens Inst. Technol. is cited in an editorial.

(157) Powder Metallurgy Conference. *Nickel Bull., 14,* 49 (1941). Abstract is given from publication issued by the Dept. of Metallurgy, Mass. Inst. Technol., in 1941.

(158) Carbonyl Iron Powder. *Product Eng., 12,* No. 7, 385 (1941). Powder of extremely small and spherical particle size is used in electrical devices and for sintered alloys, and is now produced in U. S. A.

(159) Powder Metals. *Science, 93,* Supp. No. 2420, 12 (1941). Machine parts made from powder metals under pressure in Stevens Institute of Technology are described.

(160) Defense Work Speeded by New Way of Making Parts. *Science News Letter , 39,* No. 2, 327 (1941). Use of powdered metal molded under heat and pressure is predicted by H. N. Davis, President of Stevens Inst. of Technology.

(161) Advanced Technique of Adapting Metal Powder to Industrial Use. *Steel, 109,* No. 15, 128-153 (1941). Review of Mass. Inst. Technol. Conference 1941 is presented.

(162) Progress in Powder Metallurgy. P. A. Archibald, *Mines Mag. (Colo.), 31,* 114-119 (1941). Survey of the field.

(163) Powder Metallurgy. W. J. Baëza, *Chem. Ind., 49,* No. 1, Pt. 1, 68-71 (1941). Comment on rapid progress of precision parts fabrication is made.

(164) Production of Metal Powders. C. W. Balke, *Metal Ind. (London), 58,* 502-05 (1941). The author discusses the theoretical considerations underlying successful powder metallurgy technique.

(165) Powder Metallurgy an Ancient Science. H. R. Boatman, *Metals Rev., 14,* No. 3, 8 (1941). Report on talk by J. E. Drapeau Jr., February 18, 1941.

(166) Expansion of Powder Metallurgy. D. F. Carter, *Metals Rev., 14,* No. 10, 7 (1941). Description of talk by R. P. Koehring in Indianapolis.

(167) Powder Metallurgy: Application in Mass Production of Automotive Parts. H. Chase, *Automotive Inds., 85,* No. 12, 35, 60 (1941). Its application in Chevrolet equipment is described.

(168) Powder Metallurgy. G. J. Comstock, *Compressed Gas Mfr.'s Assn. Proc. Mtg.,* Jan. 20-21, 1941, 34-38. Review.

(169) Improvements in Metal Powder Manipulation. G. J. Comstock, *Heat Treatment and Forging, 27,* 131-34 (1941). Reference made to lamp filaments, hard cemented carbides, and bearings.

(170) Machine Parts Made from Powdered Metal Masses Under Pressure. H. N. Davis, *Science, 93,* No. 2420, Suppl. 12 (1941). General review explains that articles are produced from ferrous and non-ferrous powders and cutting tools from cemented carbides.

(171) Metalloceramics. M. Engel, *Mitt. Forsch. Inst. u. Probieramts f. Edelmetalle,* Gmünd, pp. 20-28 (1941). Review of powder metallurgy raw materials, processes and products.

(172) Powder Metallurgy in National Defense. C. G. Goetzel, *The Frontier, 4,* No. 1, 4-6 (1941). General description of process and applications is given.

(173) Powder Metallurgy and the Future. H. W. Greenwood, *Metal Ind. (London), 58,* No. 19, 402-404 (1941). Developments and application of powdered metals in industry are discussed.

(174) The Manufacture of Articles from Powdered Metals. W. D. Jones, *Trans. Manchester Assoc. Engrs.,* 79-102, 103-116 (1941); *Engineer, 152,* No. 3963, 515-516 (1941-1942); *Mech. World Eng. Record, III,* No. 2873, 85-86; No. 2874, 91-93 (1941). Production of bronzes, sintered bonded Babbitt bearings, cemented carbides, Alnico magnets, iron parts and refractory metals is outlined, and the scope and limitations of powder metallurgy are discussed generally.

(175) Powder Metallurgy. F. C. Kelley, *Automotive Inds., 85,* No. 2, 34, 56, 58, 60 (1941). Abstract of paper before Eng. Soc., Detroit, on progress of sintered metals accomplished by General Electric Co.

(176) Powder Metallurgy. F. C. Kelley, *Can. Metals Met. Inds., 4,* No. 12, 322-7 (1941). Review of developments, including applications and properties.

(177) Powder Metallurgy. L. S. Marks, *Mechanical Engineer's Handbook,* McGraw-Hill, New York, 1941. Powder Metallurgy is covered on pp. 669-671; Metal powders, porous bearing metals, hard carbides are discussed.

(178) The Art of Alloy Engineering. P. D. Merica, *Metal Progress, 40,* No. 4, 425-440 (1941). Section on powder metallurgy is contained in the review.

(179) Powder Metallurgy Abroad. D. P. Neklyudov, *Tsvetnye Metal, 14,* No. 13, 37-39 (1941). A review of the field in Europe and the U. S.

(180) Powder Metallurgy – 1941 Model. F. P. Peters, *Metals & Alloys, 14,* No. 5, 721-22, 24, 26, 28, 30, 33. Report on the Mass. Inst. Technol. Conference.

(181) Powder Metallurgy Expected to Emulate Remarkable Expansion of Die Casting. F. P. Peters, *Metals Rev., 14,* No. 1, 3 (1941). Description is given of talk by E. S. Patch, dealing with powder metallurgy problems.

(182) Newer Developments in Metalloceramics. G. Ritzau, *Werkstattstechnik, Werksleiter, 35,* No. 8, 145-9 (1941). Progress in powder metallurgy; properties of sintered materials; comparisons of German and American practices are given.

(183) Recent Research Into Problems of Powder Metallurgy. D. W. Rudorff, *Metallurgia, 23,* No. 138, 167-70; *24,* No. 140, 53-56 (1941). Review of recent laboratory research on problems of powder metallurgy is presented.

(184) Powder Metallurgy Meeting. F. T. Sisco, *Mining and Met., 22,* No. 420, 596 (1941). The Mass. Inst. Technol. Conference, 1941, is discussed.

(185) Metalloceramics. C. Tama, *Ind. meccan., 23,* No. 11 (1941). General review.

(186) Sintered Metals, Their Application, Production and Properties. H. Unckel, *Tek. Tid., 71,* No. 28, 53-59 (1941); *Chem. Zentr.,* 113, Pt. I, 1422 (1941). Properties of various powdered mixtures investigated at Finspongs Metal Works, Sweden. Cu-W and Cu-graphite powders, Cu-Sn alloy, Cu-Zn, Cu-Al. Hot-pressing process is described.

(187) Cold Casting. J. Watson, *Popular Science, 138,* No. 4, 98-102 (1941). Description of a revolutionary process for making metal parts from powders.

(188) Specimens Illustrate Many Applications of Powders. W. H. Williams, *Metals Rev., 14,* No. 2, 3 (1941). Description of talk by D. O. Noel on Jan. 8 at Penn. State College.

(189) The 1941 Conference on Powder Metallurgy. J. Wulff, *Metal Progress, 40,* No. 5, 785-788, 838. General review on the Mass. Inst. Technol. Conference is presented.

(190) Sintered Parts. *Automobile Engr., 32,* 266-268 (1942). Progress in fabrication of components from compressed porous powders is reported.

(191) Powder Metallurgy. *Automobile Engr., 32,* 401-402 (1942). Recent developments are briefly discussed, including production methods, size of particles, pressure requirements, hot-pressing and porosity. Application of iron and self-lubricating bearings from bronze and graphite.

(192) Powder Metallurgy. *Commonwealth Engr., 30,* No. 1, 3-6 (1942). Consideration is given to the different stages of production of sintered compacts, sintering, and pressing.

(193) Powder, Pressure and Heat. *Fortune, 25,* No. 1, 44-7, 120 (1942). Non-professional article on advance of powder metallurgy. W-carbide uses in military equipment are described.

(194) Metal Powders. *Iron Age, 149,* No. 8, 49-53 (1942). Illustrated article on process of manufacture of powder metallurgy products.

(195) Powder Metallurgy. *Machinery (London), 61,* No. 1558, 203-06; No. 1560, 265-7 (1942). Iron powders and parts thereof, and bronze bearings are discussed, and the limitations in design are reviewed.

(196) Powder Metallurgy Assumes an Important Role. *Machinery (N.Y.), 48,* No. 3, 138 (1942). Review of recent developments.

(197) Powder Metallurgy. *Metals & Alloys, 15,* No. 6, 1025-26, 1028, 1030 (1942). A composite of abstracts is presented: Process Application trends; limitations and possibilities; pressing; vacuum in processing; iron powder-metallurgy; magnets; "heavy" alloy.

(198) More Products from Powdered Metals Rather Than Different Processes. L. H. Bailey, *Metal Progress, 42,* No. 4, 735-736 (1942). Note on recent trends.

(199) Metallurgy and Men. M. Cook, *Metal Ind. (London), 60,* No. 17, 284-7; No. 18, 305-06 (1942). Powder metallurgy is included in discussion.

(200) Non-Ferrous Metals – Metal Powder Products. G. L. Craig, *Metals & Alloys, 15,* No. 1, 46-7 (1942). Review of 1941 progress in powder metallurgy is presented.

(201) Developments in Powder Metallurgy. B. H. Dyson & D. R. Snowden, *Machinery (London), 61,* No. 1555, 119-20 (1942). Processes and progress in the field.

(202) Powder Metallurgy. J. Geschelin, *Automotive and Aviation Inds., 86,* No. 1, 28-31, 78-80 (1942). Review of its products is made, with special reference to the automotive field.

(203) The Practice of Powder Metallurgy. H. W. Greenwood, *Metal Ind. (London), 61,* No. 15, 226-7; No. 16, 242-3; No. 17, 265-6; No. 18, 279-80 (1942). This paper is intended as an introduction to the practice of powder metallurgy. Subjects treated are preparation of powders, including disintegration, graining, electrolysis, etc., sintering with special reference to carbonyl iron, atmospheres. Bibliography.

(204) Alloy Powders Produced in Quantity. H. E. Hall, *Metal Progress, 42,* No. 4, 734-35 (1942). Short note describing production developments for powdered metals in general terms.

(205) Developments in Metal Powders and Products. H. E. Hall; *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chapt. 3, pp. 18-36. Carbides, current collector brushes, bearings, grinding wheels, core bits, clutch plates are included in the survey.

(206) Powder Metallurgy as Help to National Defense. C. Hardy, *Wire & Wire Products, 17,* No. 5, 247-48, 257 (1942). General discussion of the subject.

(207) Metallic Powders. J. Hérenguel, *Usine, 51,* No. 8, 35-42 (1942); *Chem. Zentr., 113,* Pt. II, 1284 (1942). General survey is presented of the manufacture of Zn, Al, Sn, Ni, Pt, and bronze, also of such oxidizing powders as W, Ti, Fe, Co, and of their different uses in paints, as catalysts, for pyrotechnic and aluminothermic purposes, and for processing as sintered materials.

(208) Rare and Precious Metals. Z. Jeffries, *Mining and Met., 23,* 69-70 (1942). Tantalum carbide in tools and dies, Mo, W in high speed steels, Zr powder, hard metals are discussed.

(209) Powder Metallurgy Processes. W. D. Jones, *Mech. World Eng. Record, 111,* 91-3 (1942). Review given before Manchester Assoc. Engrs. includes sintering, molding to finished sizes, sintered bonded Babbitt bearings, hard metal tools, Alnico magnets, refractory metals, and hot-pressing.

(210) Powder Metallurgy. F. C. Kelley, *Electr. Eng., 61,* No. 9, 468-75 (1942). General survey of the field is presented.

(211) Metalloceramics. H. Lüpfert, *Feinmech. u. Präzision, 50,* 21-24, 49-53 (1942). General review.

(212) New Materials and Finishes of 1941. F. P. Peters, *Metals & Alloys, 15,* No. 1, 82-90 (1942). New powder metallurgy products placed on the market during 1941 are reviewed.

(213) Recent Swedish Progress in Powder Metallurgy. D. W. Rudorff, *Metal Ind. (London), 60,* 188-90 (1942). Discussion of Cu and W powders, alloys, Cu-W powders, Cu-graphite powders, Cu-Sn, Cu-Zn, and Cu-Al sinter alloys, and porous products.

(214) Metal Ceramics. F. Skaupy, *Metallwirtschaft, 21,* 64, 597 (1942). A discussion of the terms "metal ceramics" and "powder metallurgy" is presented within the framework of a broader review.

(215) Metallurgy in 1942 Devotes Itself Largely To Alternatives. R. C. Stewart, *Can. Machinery, 53,* No. 12, 161-5 (1942). Review of developments. Among others, powdered metals are discussed.

(216) Tomorrow's Metals. P. M. Tyler, *Mining and Met., 23,* No. 421, 5-8 (1942). Powder metallurgy cited among others.

(217) Sintered Metals, Their Application, Production and Properties. H. Unckel, *Tek. Ukeblad, 89,* 23-30 (1942). Cf. *Tek. Tid., 71,* No. 28, 53-59 (1941).

(218) Powder Metallurgy. F. Vanderheyden, *Gieterij, 16,* 126-130 (1942); *C. A., 38,* 3230 (1942). Compacts of metals of a high melting point, hard metals, pseudo-alloys as contact materials, self-lubricating bearings, porous bodies, and materials containing diamond slivers, are described.

(219) Powder Metallurgy Meeting in America. H. Wiemer, *Stahl u. Eisen, 62,* 800-801 (1942). A review of the powder metallurgy conference at Massachusetts Institute of Technology in 1941 is given.

(220) Powder Metallurgy. J. Wulff, *Am. Soc. Metals,* Cleveland, 1942, 622 pp. Symposia of papers presented at the 1940 and 1941 conferences at M.I.T. on Powder Metallurgy, edited by J. Wulff. Textbook. All chapters are carried in this bibliography under the different authors and are classified according to the individual subject.

(221) Powder Metals Find Wide Use. *Am. Machinist, 87,* No. 13, 83-86 (1943). Savings of material, particularly Cu, elimination of scrap losses, savings of manpower and costs are discussed.

(222) Powder Metallurgy. *Can. Metals Met. Ind., 6,* No. 4, 25-7 (1943). Abstract is given of Symposium of A.S.T.M. Meeting in Buffalo.

(223) Symposium on Powder Metallurgy. *Industrial Heating, 10,* No. 4, 484-88 (1943). Report is given on A.S.T.M. Spring meeting in Buffalo and short description of papers presented.

(224) Powder Metallurgy Used for War Production. *Industrial Heating, 10,* No. 12, 1810-1812 (1943). Metal shaping technique as used by Westinghouse Co. to aid war production is described. Magnets from Fe powder for electrical circuit breakers and W-filaments are included in the review.

(225) Condensed Review of Some Recently Developed Materials. *Machinery (N.Y.), 50,* No. 2, 177-81; No. 3, 189-93 (1943). Included are trade names of metal powders.

(226) Powder Metallurgy in U. S. *Metal Ind. (London), 62,* No. 11, 172 (1943). According to U. S. Pat. 2,294,404 by F. R. Hensel and E. I. Larsen, Ag powders can be formed into heavy duty bearings by sintering. Lead powders can be admixed to improve the lubricant qualities. Comparative results with Al-Cu powder products and Al-Cu casting alloys are given.

(227) Powder Metallurgy. *Metals & Alloys, 17,* No. 5, 1046-8 (1943). Highlights of the March 1943 A.S.T.M. Symposium on powder metallurgy are presented in form of abstracts of papers.

(228) Powder Metallurgy Grows. *Mining and Met., 24,* 345 (1943). Plans being perfected for sessions on powder metallurgy at February 1944 meeting of the Am. Inst. Mining Met. Engrs.

(229) War-Time Developments in Powdered Metal Parts. *Product. Eng., 14,* No. 8, 472-75 (1943). Advantages of powder metallurgy; table with properties of pressed metal powders produced by 5 companies is presented.

(230) Present Status of Powder Metallurgy. *Tool & Die J., 9,* No. 5, 87-91 (1943). Survey contains pictures of finished parts; applications of high melting-point metals; cemented carbides; porous metal parts; composite metals; frictional metals.

(231) Symposium on Powder Metallurgy, *Am. Soc. Testing Matls.*, Philadelphia, Pa., Sept. 1943, 55 pp. Fundamentals necessary to apply powder metallurgy; effect of pressure on properties of compacts; influence of homogenization upon physical properties of copper-nickel powder alloys; effect of particle size on shrinkage of metal compacts; alloy powders; metal powder friction materials; hot pressing of metal powders. Discussion for each paper. (All papers are classified in this bibliography according to topic.)

(232) War Metals and Substitutes. F. H. Allison, *Industrial Heating, 10,* No. 2, 201-204 (1943). Conservation of metals and alloys vital to war effort. Discussion includes powder metallurgy.

(233) A Course in Powder Metallurgy. W. J. Baëza, *Reinhold,* New York, 1943, 212 pp. History and modern development; production of powders, specifications, particle size, cohesion; manufacturing problems and machines. Course of instruction presented with laboratory equipment and costs.

(234) Powder Metallurgy. H. Bernstorff, *Chem. Fabrik, 16,* 89-98, 102-105 (1943). A discussion of principles and applications is presented.

(235) Processing and Application of Metal Powders. C. S. Darling, *Mech. World Eng. Record, 114,* No. 2961, 375-8 (1943). Compressibility, advantages and applications, use of alloy powders including Al, Cu, W, Ni and Fe, and particle size determination are discussed.

(236) Powder Metallurgy. W. H. Dennis, *Industrial Chemist, 19,* No. 216, 29-34 (1943). Products – some recent developments, manufacture of powders, particle shape, physical methods, pressing dies, applications, cemented carbides, bearings, hydrides are discussed.

(237) Powder Metallurgy. O. W. Ellis, *Can. Chem. & Process Ind., 27,* No. 7, 382-6, 415 (1943). Fundamentals in the production of molded parts for engineering purposes are presented.

(238) Powder Metallurgy. O. W. Ellis, *Can. Metals Met. Ind., 6,* No. 7, 26-30 (1943). Fundamentals in the production of molded parts for engineering purposes, powder preparation and properties, die design, effect of particle size, etc., are presented.

(239) Powder Metallurgy. J. H. Frye, *Army Ordnance, 24,* No. 138, 499-501 (1943). Step-by-step account of the method is given, with particular attention to sintering.

(240) The Fundamentals Necessary to Apply Powder Metallurgy. C. Hardy, in *Symposium on Powder Metallurgy,* Am. Soc. Testing Matls., Philadelphia, Pa., 1943, pp. 1-10. Raw materials and powder preparation; applications are discussed.

(241) On the Production of Synthetic Metallic Bodies. O. H. Hummel, *Der deutsche Metallmarkt, 22,* 36 (1943). Outline of the field is given.

(242) Powder Metallurgy. W. D. Jones, *Can. Metals Met. Ind., 6,* No. 10, 31-4, 53 (1943). A concise statement of current manufacturing practice of powder metallurgy, and a listing of some powder metallurgy products and their applications is presented.

(243) Powder Metallurgy: Its Products and Their Various Applications. W. D. Jones, *North East Coast Inst. Engrs. & Shipbuilders Trans., 59,* No. 5, 139-146 (1943). Advantages are considered and examples cited in which technique would be of interest in field of marine engineering.

(244) Powder Metallurgy. W. D. Jones, *Overseas Engineer, 16,* No. 186, 132-135 (1943). A general review. Extracts from paper given to the North East Coast Institution of Engineers and Shipbuilders.

(245) Powder Metallurgy. W. D. Jones, *J. Soc. Chem. Ind., 62,* No. 9, 78-81, (1943). Some of principal articles and methods are described; advantages of powder metallurgy technique, porous bronzes, hard metal tools, etc. are cited.

(246) Developments in Powder Metallurgy. P. R. Kalischer, *Mining J. (Phoenix, Ariz.), 27,* No. 10, 8 (1943). Description is given of practice of Westinghouse Electrical & Mfg. Co. in manufacturing small parts and wire filaments.

(247) Powder Metallurgy. F. C. Kelley, *Metals & Alloys, 17,* No. 1, 88-89 (1943). Review of developments in 1942; it is stated that year has not been highly productive of new things in powder metallurgy due to curtailment of production.

(248) Powder Metallurgy. F. C. Kelley, W. A. Reich and C. D. MacCracken, *Materials and Processes,* Wiley, New York, 1943, pp. 378-386. Edited by J. F. Young. One of a series written in the interest of the General Electric Advanced Engineering program.

(249) Powder Metallurgy and Sintered Metals. R. Kieffer and W. Hotop, *Pulvermetallurgie und Sinterwerkstoffe,* Springer, Berlin, 1943, 403 pp. 1st part: description of metal powder and properties and technology of production of metal bodies; 2nd part: scientific basis of powder metallurgy; 3rd part: discusses sintered metals grouped according to the periodic system; 4th part: sintered metals of special importance.

(250) Sintered Matter. R. Kieffer and W. Hotop, *Jahrbuch der Metalle,* Lüttge-Verlag, Berlin, 1943. On pp. 172-183 sintered substances in nature and sintered materials in industry are discussed.

(251) Alloy Powders. T. H. Lashar, in *Symposium on Powder Metallurgy,* Am. Soc. Testing Matls., Philadelphia, Pa., 1943, pp. 41-43. A general review gives the advantages of alloy powders in sintering procedures.

(252) Our Debt to the Metallurgist. L. W. Law, *Engineer (London), 176,* No. 4577, 264-65 (1943). Author pays tribute to achievements of metallurgists in past 5 years, touching upon different subjects including cutting tools and powder metallurgy.

(253) Powder Metallurgy. F. V. Lenel, *Mechanical Eng., 65,* No. 6, 450-453; No. 7, 489-492. Topics discussed are powder specifications, mechanical properties, multiple punches for even density throughout. Density of 6.5 obtained for iron powder with 0.2% C. Mechanical properties of iron powder products suitable for small arms components are presented.

(254) The Mechanical Properties of the Products of Powder Metallurgy. F. V. Lenel, *Metallurgia, 28,* No. 166, 189-192. Attention is directed to some of the difficulties encountered in the preparing of iron powder; suggestions are made for setting up detailed specifications likely to ensure the quality and the uniformity of production.

(255) Powder Metallurgy Demonstrated in Boston. C. G. Lutts, *Metals Rev., 16,* No. 3, 6 (1943). Report on talk by J. Wulff in Boston on Feb. 5; gear-hardening, tolerances, applications were discussed.

(256) Powder Metallurgy. W. F. Nash, Jr. and D. S. Clark, *Western Metals, 1,* No. 6, 8-10 (1943). Procedure of making objects from powders involves two steps: formation of compact by compression of individually mixed or alloyed metal powders in dies, and heating or sintering of compacts. Advantages of process are discussed.

(257) Powder Metallurgy. N. G. Neuweiler, *Tech. Ind. Schweiz. Chem. Ztg., 26,* 61-5, 92-7 (1943). A general review of the subject is presented.

(258) Powder Metallurgy. F. M. Reck, *Aero Digest, 42,* No. 1, 170-174 (1943). Discussion is presented of machine parts from powdered metals developed at Amplex Div. of Chrysler Corp., with more than 6000 different units being manufactured for war equipment.

(259) Report on the Mass. Inst. Technol. Symposium, 1940. K. Sedlatschek, *Kolloid-Z., 104,* No. 2/3, 254-55 (1943). Mostly taken from *Metals & Alloys, 12,* No. 4, 471 (1940).

(260) Metalloceramics. F. Skaupy, *Metallkeramik,* Verlag Chemie, Berlin, 3rd ed., 1943, 250 pp. Production of metallic bodies from metal powders; metallurgy of sintered metals and alloys; products; technology of metal powders. 1st edition 1930, 2nd edition 1935.

(261) New Powder Metallurgy Products. E. E. Thum, *Metal Progress, 43,* No. 3, 412 (1943). The following are pointed out: powder metal compacts of large size; ball bearing retainer rings 20" in diameter, 12" sleeve bearings, 8" long, plates weighing 60 lbs., and solid bars, 7" diameter x 6½" long made by Chrysler Corp. Amplex Div.; 100 parts made by powder metallurgy for simple anti-aircraft gun working at 200-270° F. (93-132° C.).

(262) Many Metals Now Adapted to Powder Methods. C. S. White, *Metals Rev., 16,* No. 3, 2 (1943). Report on talk by J. Wulff in Toronto, Jan. 8, 1943, covering cold pressing, sintering, contacts, Fe, Al and Mg.

(263) A Review of Raw Material Sources. C. E. Williams, *Chem. Eng. News, 21,* 1635-40 (1943). Postwar products planning; powder metallurgy is one of the subjects mentioned.

(264) Powder Metallurgy. J. Wulff, *Can. Metals Met. Ind., 6,* No. 2, 30, 42 (1943 Talk before Ontario Chapter of Am. Soc. Metals in January 1943 was a review of recent developments and technical aspects.

(265) Developments in Powder Metallurgy. J. Wulff, *Metal Ind. (London), 62,* No. 23, 362 (1943). Extracts from paper given before Am. Soc. Metals, Ontario Chapter, in January, 1943.

(266) Powder Metals. *Business Week,* No. 791, 74-76, 77-80 (1944). Broad outlines of the art, its major exponents, some applications and post-war future are presented.

(267) Files of Director of Iron Foundry Research, Technical University, Aachen (1944). F. D. Report No. 2247/44. Contains information on physical and chemical reactions during the iron-sintering process; the preparation of metal powders by Hametag, D. P. G., Mannesmann, pressure-atomizing, reduction and carbonyl processes; sintered bearings. Covers period of 1942-44.

(268) Powder Metallurgists Present Technical Advances. *Iron Age, 153,* No. 22, 55-58, 135-137 (1944). During the first annual spring meeting of the Metal Powde Association in New York on May 5, 1944, the following papers were presented: "Electrolytic Iron Powders" by B. T. Du Pont; "Reduction of Metal Powders" b J. E. Drapeau, Jr.; "Electrolytic Copper Powder" by G. B. Smith; "Special Test and Standards to be Used in Powder Metallurgy" by J. F. Sachse; "Powder Metallurgy Merry-Go-Round" by S. K. Wellman and J. Wulff; "Technical Requirements of Metal Powders" by E. Patch; "Aluminum Powders" by A. Galbraith; "Powder Metals as Viewed by the Army" by J. L. Pasternak; and "How a Solid Metal Fabricator Views Powder Metallurgy," by D. K. Crampton.

(269) Powder Metallurgy Developments Discussed. *Iron Age, 154,* No. 23, 126 (1944). Report on talk by R. P. Koehring at Pittsburgh. History of powder metallurgy, advantages, applications are reviewed.

(270) New Studies on Metals and New Metallurgical Techniques. *Metal Progress 45,* No. 4, 698-702 (1944). Am. Inst. Mining Met. Engrs. February meeting described and some papers on powder metals are discussed.

(271) Products from Metal Powders. *Modern Industry, 8,* No. 4, 33-36 (1944). An illustrated article shows new trends, accuracy and no scrap, savings, porosity and a promising future.

(272) Metal Powders. *Sci. American, 171,* 153 (1944). Post-war uses for Al and other powders are discussed.

(273) Latest Developments in the Art of Powder Metallurgy. P. D. Aird, *Modern Industrial Press, 6,* 36, 40, 54 (1944). Postwar techniques are described.

(274) What is Powder Metallurgy? W. J. Baëza, *Chemist, 21,* No. 6, 375-85 (1944 Advantages and techniques are considered as field for applications in chemistry.

(275) Powder Metallurgy and "Magal" Age. J. L. Bray, *Industry & Power, 46,* 62-4, 120 (1944). An analysis is made of advantages and limitations of process of making products from mixtures of metal powders.

(276) Powder Metallurgy: A.— Manufacturing Methods and Limitations. J. H. Bul *Austral. Inst. Metals: Australasian Eng. Science Sheet* (Sept. 7, 1944) 1-4. Methods of manufacturing parts by powder metallurgy are covered in a general discussion.

(277) Some Aspects of Powder Metallurgy. J. C. Chaston, *Metal Treatment, 11,* No. 37, 15-18, 36 (1944). Survey of subject is presented, mainly on basis of papers presented at recent conferences held in U.S.

(278) Powder Metallurgy. V. Chiaverini, *Engenharia, 3,* No. 28, 133-54 (1944). Historical outline and a detailed review is given, including preparation of metal powders; mixing; compressing; sintering; products manufactured by powder metallurgy; refractory metals; combinations of metals and non-metals; hard cemented carbides; electric commutator brushes; friction materials and porous bearings. Advantages, disadvantages and recent developments.

(279) Powder Metallurgy. V. Chiaverini, *Inst. Pesquisas Tecnol., São Paulo, Sep.,* No. 114, 25 pp. (1944). A review with 23 references.

(280) Technical Reports on Meeting of the Metal Powder Association. F. H. Clark, *Iron Age, 153,* No. 22, 58-59 (1944). Report of the second day's meeting in New York, May 4-5, 1944.

(281) Powder Metallurgy. F. H. Clark, *Mining and Met., 25,* No. 446, 81, 95 (1944). Several applications in ordnance but little experimentation in untested field is found in this general review.

(282) Parts from Metal Powders. C. Claus, *Aeronautical Eng. Rev., 3,* No. 5, 47-49, 145 (1944). Definition and origin of powder metallurgy; accomplishments, production of porous structures, accurate dimensions without machining, etc.; limitations are discussed.

(283) The War's Foremost Achievements in Materials and Methods – A Survey. E. F. Cone, *Metals & Alloys, 20,* No. 4, 916-921 (1944). Powder metallurgy among others is cited, and the especially expanded use of carbide tools is described.

(284) Chemical Research. C. Eddison, *Electronic Inds., 3,* No. 11, 98-100, 224 (1944). Iron cores are included in a brief survey of research in allied fields which has contributed to advance in electronics equipment.

(285) Powder Metals – An Outline for Scientific Studies. C. Hardy, *Metal Progress, 45,* No. 4, 690-691 (1944). Different production methods and powder characteristics are outlined.

(286) Machine Shop Methods. H. H. Jackson, editor, *Engineering Production Annual, 1944,* P. Elek, London, 102 pp. Review is presented of development during 1943 in machine shop methods, machine tools, powder metallurgy, etc.

(287) Powder Metallurgy. W. D. Jones, *Aircraft Production, 6,* No. 67, 226-229 (1944). A survey of the possibilities of this technique is given. Dimensional changes, limitations of process, porous bearings, contact materials, etc. are discussed.

(288) Powder Metallurgy. W. D. Jones, *J. Inst. Product. Eng., 23,* 35-58 (1944). Equipment for small experimental laboratory is discussed, and properties of different products obtained by hot pressing are reviewed.

(289) How to Commence Production in Powder Metallurgy. W. D. Jones, *Machinery (London), 64,* No. 1647, 497 (1944). Brief discussion of equipment and laboratory required and choice of product. Extract of paper before the Institution Production Engineers.

(290) Powder Metallurgy. P. R. Kalischer, *Metals & Alloys, 19,* No. 1, 82-83 (1944). Review of recent progress.

(291) Use of Very Fine Metal Powders Introduces Problems in Production. T. Lyman, *Metals Rev., 17,* No. 12, 4 (1944). Report on talk by C. Hardy at Notre Dame University on preparation of metal powders including ultrafine grades, testing, and means of using these raw materials in the production of useful objects.

(292) Powder Metallurgy Enters Second Era. C. Nagler, *Metals Rev., 17,* No. 3, 8 (1944). Talk by G. J. Comstock in Minneapolis February 1944 is discussed.

(293) Powder Metals as Viewed by the Army. J. L. Pasternak, *Iron Age, 153,* No. 22, 135 (1944). Abstract of a paper presented at the First Annual Spring

Meeting of the Metal Powder Assoc., New York, May 5, 1944. A general review is given of the multitude of applications of powder metallurgy in the military field, with special reference to porous bearings and sintered parts.

(294) **Materials and Methods Manual.** F. P. Peters, *Metals & Alloys, 20,* No. 1, 90-104 (1944). A classification of production methods is presented according to process features, advantages, typical parts, production methods, cost factors, production speeds and design factors, physical properties; included are powder metallurgical parts.

(295) **Card-Indexing.** G. H. S. Price, *Metal Ind. (London), 64,* No. 23, 354-6 (1944). Description of Cope-Chat Paramount Sorting System now applied to powder metallurgy.

(296) **Powder Metallurgy.** W. I. Pumphrey, *Automobile Engr., 34,* No. 457, 547-8 (1944). Application of powder metallurgy in automobile industry is described: advantages; hard alloy tools; porous bearing alloys; sintered iron gear wheels; electrical components and welding rods.

(297) **Report on Committee B-9 on Metal Powders and Metal Powder Products.** W. A. Reich and W. R. Toeplitz, *A.S.T.M. Preprint No. 20,* 1944, 3 pp.; *Met. Abstr., 11,* 334 (1944). A review of the activities of the various sub-committees.

(298) **Powder Metallurgy: B. Applications, Uses and Trends.** J. H. Robinson, *Australian Inst. Metals: Australasian Eng. Science Sheet 5-7 (Sept. 7, 1944).* The advantages of applying powder metallurgy to the manufacture of a wide variety of articles are discussed.

(299) **Materials and Methods Manual 2, Powder Metallurgy.** E. E. Schumacher and A. G. Souden, *Metals & Alloys, 20,* No. 5, 1327-1342 (1944). Covers an introduction and history of the field's development and a review how metal powders are made, operations, products and applications, and advantages and limitations. 68 references – Appendix tables on metal powder suppliers and manufacturers of presses and parts and products. Detailed information.

(300) **Principles of Powder Metallurgy.** F. Skaupy, Philosophical Library, New York, 1944, 80 pp. An English translation of the first edition (1930) of the author's book *Metallkeramik.*

(301) **Iron in Powder Metallurgy.** R. J. Traill, *Trans. Can. Inst. Mining Met., 47,* 490-500 (1944). General survey includes raw material; electrolytic iron; sponge iron; oxide reduction; furnaces; physical characteristics of iron powder, specifications; fabricating procedures; present and future development.

(302) **Industrial Research Progress at the Armour Research Foundation 1943-1944.** H. Vagtborg, *Chem. Eng. News, 22,* No. 23, 2088-2102 (1944). Powder metallurgy was among other subjects investigated, and particle size distribution of metal powder studied.

(303) **Powder Metallurgy Merry-Go-Round.** S. K. Wellman and J. Wulff, *Iron Age, 153,* No. 22, 58 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Powder Metallurgy was likened to a three-ring merry-go-round, in which the center group represents those working in the patent field, the next the courts making decisions in patent litigations, and the outermost ring represents producers and consumers.

(304) **Powder Metallurgy.** S. V. Williams, *G. E. C. J., 13,* 3-9 (1944). A general survey is made of powder metallurgy and the processes for the molding and sintering of powders. Applications reviewed; methods of producing powders shown; curves to show effect of sintering temperature on the density of compacts pressed at different pressures are presented.

(305) **Powder Metallurgy.** S. V. Williams and G. H. S. Price, *Mining Mag., 71,* No. 3, 137-48 (1944). Review is given of development and application of powder metallurgy, including a discussion of probable future progress.

(306) **Emery Graves Gilson – Pioneer in Powder Metallurgy.** J. Wulff, *Metal Progress, 46,* No. 4, 717 (1944). An appreciation on the occasion of Mr. Gilson's 75th birthday.

(307) Metal Powders and Metal Powder Products. *A. S. T. M. Bull., 133,* 45 (1945). Meeting of the B-9 Committee on Metal Powders in Feb. 1945 has acted on proposed tentative specifications for sintered oilless bearings.

(308) Powder Metallurgy. *Automobile Engr., 35,* No. 466, 368 (1945). Some aspects of modern applications of powder metallurgy are briefly discussed.

(309) Powder Metallurgy. *Industrial Heating, 12,* No. 1, 60-66 (1945). Report on talk by R. P. Koehring in Pittsburgh, Nov. 9, 1944. Development of powder metallurgy, preparation of powders, testing, pressing, sintering, and applications were discussed.

(310) Powder Metallurgy Research Planned at National Bureau of Standards. *Industrial Heatg., 12,* No. 4, 662 (1945). Powders and processing methods will be studied.

(311) Powder Metallurgy. *Inst. Production Engrs., 24,* No. 3, 73-84 (1945). Paper presented to Institution, Derby Sub-Section on Dec. 18, 1944, by E. M. Trent.

(312) Highlights on Powder Metallurgy. *Iron Age, 155,* No. 4, 60 (1945). A brief review.

(313) Success of Powder Metallurgy in War Production. *Iron Age, 155,* No. 7, 130-132 (1945). Report is given on talk by G. J. Comstock before Am. Soc. Mech. Engrs. in N. Y. on commercial aspects of applied powder metallurgy.

(314) Highlights of Powder Metallurgy. *Iron Age, 155,* No. 12, 116 (1945). Talk by Z. Jeffries at Stevens Institute is discussed. Cemented carbides, tungsten filaments cited as practical application.

(315) Powder Metallurgy Production of Machine Parts. *Machinery (London), 67,* 337-43 (1945). Deals with powder metal applications at the Chrysler Amplex plant.

(316) Powder Metal Products Essential to War Production. *Machinery (N. Y.), 51,* No. 7, 166 (1945). Report on talk by G. J. Comstock before Am. Soc. Mech. Eng. in New York is given.

(317) Materials and Methods Manual 9: Powder Metallurgy Materials. *Materials & Methods, 22,* No. 4, 1112 (1945). New powder metallurgy products developed during the war by different companies including "Sinteel," "Pomet," and "Mrco" series.

(318) Powder Metallurgy. *Metal Ind. (London), 67,* 137 (1945). Production, design limitations, possibilities are briefly reviewed.

(319) Powdered Metals Have Wide Application. *Petroleum World, 42,* 49-51 (1945). Porosity, strength and self-lubrication are the highly useful combination of qualities that are built into powder metals.

(320) Technical Advisory Service Regarding Powder Metallurgy. *Smaller War Plants Corp., Region 3, Report No. 1-BO-117 – Metals,* Philadelphia, Pa. (Apr. 4, 1945). Twenty experts try to answer inquiry by potential competitor.

(321) Powder Metallurgy Affords Various Advantages. R. B. Aufmuth, *S. A. E. Journal, 53,* No. 7, 44-45 (1945). Method of production, and advantages of metal powders are discussed.

(322) Powder Metal Parts. G. W. Birdsall, *Steel, 116,* No. 16, 106-9, 150-153, 154, 156, 158 (1945). Increased physical properties made possible through development of better methods of powder manufacture and control and greater knowledge of processing.

(323) What's New in Non-Ferrous Metals. A. Black, *Machine Design, 17,* No. 10, 129-132 (1945). Short paragraph on cemented carbides is included.

(324) Some Recent Developments in Engineering Materials. A. Black, *Mechanical Eng., 67,* No. 5, 334-43 (1945). Powder metallurgy and sintering covered among other subjects.

(325) Deutsche Edelstahlwerke, Krefeld: Report on High Alloy Steel Production. H.M. Brightman, G.J. Comstock, J.D. Dickerson, T.G. Foulkes, R.A. Gezelius, S.F. Grover, G. Meikle, C.F. Park, and H.C. Smith, C.I.O.S. Rept. No. XXV-38,

(1945). Interrogation of Dr. H. Gehm. Details of his various activities, including discussion of Alnico-type sintered magnets, are reported.

(326) **Powder Metallurgy: A. Manufacturing Methods and Limitations.** J. H. Bull, *Iron & Steel Inst. Bull., 109,* 74A (1945). Methods of manufacturing parts by powder metallurgy.

(327) **Enemy Materiél from the Metallurgical Point of View.** J. R. Cady, H. W. Gillett, and L. H. Grenell, *Metal Progress, 47,* No. 2, 289-320 (1945). Reference is made to iron powder bands; projectiles with tungsten-carbide cores are described.

(328) **Powder Metallurgy Technique.** E. V. Crane and A. G. Bureau, *Western Machy. & Steel World, 36,* No. 3, 98-103 (1945). Various processes in powder metallurgy are explained and proper techniques in each stage are presented.

(329) **Molybdenum.** W. H. Dennis, *Mine and Quarry Eng., 10,* No. 5, 119-123 (1945). General review. Molybdenite and wulfenite ores, and their concentration; production and uses of the metal are described.

(330) **Compressed Powder or Sintered Metal Alloys.** H. Godfroid, *Soc. des Ingen. de l'Automobile, 18,* No. 6, 173 (1945). Manufacturing principles, properties and applications of powdered metals are described.

(331) **From Silicate Ceramics to Metal Ceramics.** M. Hauser, *Schweiz. Bauztg., 125,* 282-284 (1945). A discussion of methods in silicon ceramics precedes a description of procedure for obtaining metal ceramics.

(332) **Powder Metallurgy Precision Parts.** R. Hradecky and R. P. Seelig, *Iron Age, 156,* No. 13, 50-54, 132 (1945). Postwar possibilities and new techniques, new powder alloys and mixtures. Development of new sintered iron ("Pomet-300") described and coercive force and maximum permeability plotted.

(333) **Powder Metallurgy.** R. P. Koehring, *Ind. Heating, 12,* No. 1, 60, 62, 64, 66 (1945). History, manufacture of powder, typical plant operations, principles of pressing, future possibilities are discussed in extracts from paper given before the Am. Soc. Metals.

(334) **New York Chapter Has Lecture Series on Powder Metallurgy.** G. A. Landis, *Metals Rev., 18,* No. 1, 2 (1945). Talks by E. H. Kelton, J. Kurtz, J. J. Cordiano, L. H. Bailey, H. C. Bostwick, W. J. Hayman, J. F. Kuzmick are discussed.

(335) **Powder Metallurgy.** A. J. Langhammer, *Refrig. Eng., 49,* 26-27, 41, 55 (1945). Future possibilities of the art are wide in scope. Manufacture of Oilite bearings and significant data on powder metallurgy are included in discussion by J. Sasso.

(336) **Porous Metal in Industry.** J. W. Lennox, *Power & Works Engr., 40,* No. 466, 77-8 (1945). Data on available material of this type are given. Some of the applications are discussed.

(337) **Stamped from Metal Dust.** H. Manchester, *New World of Machines,* Random House, New York, 1945, Chap. 13. General chapter on powder metallurgy and the pioneers who helped to develop it.

(338) **Application of Powder Metallurgy.** E. V. Paterson, *Ind. Power & Production, 21,* No. 239, 361-3, 365-6 (1945). Description is given of techniques employed in making components from metal powders, and properties of resulting parts.

(339) **Powder Metallurgy.** F. P. Peters, *Metals & Alloys, 21,* No. 1, 116 (1945). Part of "Developments and Trends in Fabrication and Treatment" - a series of articles. New powders available during 1944, and double-acting presses described.

(340) **Miracle or Mirage.** F. P. Peters, *Sci. American, 173,* 99-101 (1945). Powder metallurgy can thank the automotive industries for much of its recent expansion.

(341) **Machine Parts and Bearings Fabricated from Powder Metals.** G. E. Platzer, *Tool Engr., 14,* No. 12, 36-39 (1945). Advantages of powder metallurgy are cited.

(342) **Powder Metallurgy.** G. H. S. Price, *Electrodepositor's Tech. Soc. J., 20,* 147-153 (1945). Brief general review of the subject is presented.

(343) Precision Casting, Powder Metallurgy and Silver Brazing Covered in Symposium. J. M. Redinger, Jr. and M. H. Knapp, *Metals Rev., 18,* No. 3, 13 (1945). Talk before Rhode Island Chapter Am. Soc. Metals by W. P. Matthew on powder metallurgy technique is discussed.

(344) Symposium on Production and Design Limitations and Possibilities for Powder Metallurgy Parts. F. N. Rhines, *Trans. Am. Inst. Mining Met. Engrs., 161,* 525 (1945). Foreword. (Papers listed separately).

(345) Powder Metallurgy: B. Applications, Uses and Trends. J. H. Robinson, *Iron & Steel Inst. Bull. 109,* 74A (1945). The advantages of applying powder metallurgy to the manufacture of a wide variety of articles are discussed.

(346) New Production Methods. A. A. Schwartz, *Tool Engr., 15,* No. 1, 38-40 (1945). Resume of paper before Am. Soc. Tool Engrs. Powder metallurgy among topics discussed.

(347) Postwar Horizons for Powdered Metals. P. Schwarzkopf and A. Reis, *Am. Machinist, 89,* No. 16, 99-103 (1945). Report on operating conditions established in commercial production of powder metal parts. Factors of importance for quality discussed.

(348) Workshop Yearbook and Production Engineering Manual, I. H. C. Town, *Paul Elek Ltd.,* Africa House, London, 1945, 542 pp. Part III contains 50 long abstracts from current technical press, dealing with powder metallurgy among others.

(349). Powder Metallurgy. E. M. Trent, *J. Inst. Product. Engrs., 24,* 73-84 (1945). A general review of the subject is presented.

(350) War Turns Page in Metal Processing. *Am. Machinist, 90,* No. 3, 89-104 (1946). Report on wartime developments in metals and processing methods. Powdered metals are among topics discussed.

(351) Committee B-9 on Metal Powders and Metal Powder Products. *ASTM Bull., 139,* 61 (1946). Meeting in Chicago of B-9 Metal Powder Committee is reported.

(352) Industrial Research Progress at Armour Research Foundation 1944-1945. *Chem. Eng. News, 24,* No. 4, 167 (1946). Powder metallurgy research progress is reported.

(353) Spring Meeting of Metal Powder Association. *Chem. Eng. News, 24,* No. 14, 1906 (1946). Brief summary of some papers read on June 13, 1946 at meeting of Metal Powder Association.

(354) Powder Metallurgy. *Iron Age, 157,* No. 1, 272 (1946). Report on talk by W. J. Baëza before Philadelphia Chapter of Am. Inst. Chemists.

(355) Engineers Study Technological Problems. *Iron Age, 157,* No. 10, 60-68 (1946). Papers presented at A.I.M.E. symposium, February 1946, in Chicago briefly described.

(356) British Developments in Powder Metallurgy Techniques Reviewed. *Iron Age, 157,* No. 19, 146-148 (1946). Report is given on talk by W. D. Jones at Stevens Institute of Technology on April 24, 1946.

(357) Two New Methods of Using Powdered Metal. *Ironmonger's Weekly, 1745,* 572-573 (1946). 2 powdered metal products are described: (1) a copper-base bearing alloy containing Ni 2.4, Si 0.8, and P 0.3%; and (2) a sintered mass of pulverized steel impregnated with a molten Cu alloy containing 15% Sn, Si, Cr, and other constituents.

(358) Powder Metallurgy: Key to High Temperature Application. *Machinery Lloyd, 18,* No. 4, 95 (1946). Review of research projects of Am. Electro Metal Corp. is given; includes finding combination of refractory metals and ceramics, which resist high temperature. Combination of metals and plastics. Development of high strength alloy steel.

(359) Two Metal Powder Applications. *Materials & Methods, 23,* No. 1, 344 (1946). Two coming developments described: *(1)* extruding of W powder into very small tubing for electronic parts; *(2)* a process for hard facings of powder parts.

(360) **Powder Metallurgy.** *Metal Ind. (London), 68,* No. 23, 455 (1946). Methods for reducing internal unsoundness of pressings are described together with factors involved; reference made to previously published articles regarding the mechanism of sintering, etc.

(361) **A. I. M. E. Notes on the 1946 Meeting.** *Metal Progress, 49,* No. 4, 780-782, (1946). Powder Metallurgy Symposium briefly described.

(362) **Discussion – Powder Metallurgy Symposium.** *Metals Technol., 13,* No. 5, T. P. 2047 (1946). Discussion of papers on Powder Metallurgy presented during Chicago February 1946 meeting of A. I. M. E.

(363) **Powder Metallurgy.** *Métallurgie, 78,* No. 7, 3-6 (1946). Subject is discussed in general terms.

(364) **Research Metallurgists Discuss Problems Freely at Institute of Metals Division Sessions.** *Mining & Metallurgy, 27,* No. 472, 227 (1946). Report on sessions on powder metallurgy during Chicago meeting of the Am. Inst. Mining Met. Engrs., February 1946.

(365) **Uniform Metal Powder.** *Sci. American, 175,* No. 6, 200 (1946). Ultrafine Cu powder permits manufacture of larger parts because pressure per unit area can be smaller. Uniform ultrafine particles give parts with higher density, hardness, strength.

(366) **Higher Strength Alloy Iron Powder Needed, Metal Powder Industry Told.** *Steel, 118,* No. 25, 130 (1946). Short description of papers read before Metal Powders Assoc., June 13th meeting in New York.

(367) **Powder Metallurgy.** *Wire Ind., 13,* 561. Basic principles of its application to tungsten dies and copper screening are cited.

(368) **Powder Metallurgy.** M. Yu. Bal'shin, F. D. Report No. 1726/46 (1946). A typewritten translation of the textbook in German, dated 1938.

(369) **Metallgesellschaft A. G. and the Lurgi Group of Chemical Engineering Companies.** W. R. Beswick and N. C. Fraser, B. I. O. S. Final Rept. No. 335 (1946). A few incidental details on the D. P. G. and the V. D. M. Sintermetallwerke within the framework of the Metallgesellschaft are given.

(370) **Metallwerk Plansee, Reutte.** G. M. Butler, C. I. O. S. Rept. No. XXX-8 (1946). Description of production at this plant of such items as Alnico magnets, bearings, carbide liners, driving bands, electrodes, diamond cutting wheels and disks, and piston rings.

(371) **Metallwerk Plansee, Reutte.** G. M. Butler, U. S. Dept. Comm. PB. 1834/1945, 25 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 2, 124 (1946). Details of practice and products of this powder metallurgy factory are discussed. A table gives physical and mechanical properties of German hard metal types, and standards of hard metal grades.

(372) **German Iron and Steel Industry in the Ruhr and Salzgitter Areas.** T. P. Colclough, C. I. O. S. Rept. No. XXXII-119 (1946). Brief reference to shell driving bands and carbide production is made.

(373) **Powder Metallurgy in Germany.** G. J. Comstock, U. S. Dept. Comm. PB. 19689/1945, 271 pp., *Bibl. Scient. & Ind. Rept., 1,* No. 24, 1491 (1946). Report of the combined J. I. O. A. and B. I. O. S. trip to investigate the field. Plants are visited and persons interrogated.

(374) **German Powder Metallurgy.** G. J. Comstock, U. S. Dept. Comm. PB. 39354-56/1945, 3 vol., 138, 145, 201 pp.; *Bibl. Scient. & Ind. Rept., 3,* No. 1, 36 (1946). The information contained in the reports was secured by contacting key German technical and operating personnel.

(375) **Powder Metallurgy – An Industry Founded Upon the Modern Press.** J. G. Cowley, *Modern Industrial Press, 8,* No. 3, 26-28 (1946). General process described, and concerns active in development of powder metallurgy cited.

(376) **Powder Metallurgy.** A. S. Darling, *Mech. World, Eng. Record, 119,* 368-370 (1946). Principles as applied to fabrication of small parts are presented.

(377) Powder Metallurgy. T. C. DuMond, *Materials & Methods, 23,* No. 1, 123-24 (1946). Review of progress during the war years and new products are described.

(378) Current Problems in Powder Metallurgy. F. Eisenkolb, *Die Technik, 1,* No. 10, 173-178 (1946). Review suggests to overcome existing difficulties, e. g., that obsolete techniques may have to be discontinued; that bearing tests should be conducted "in vivo"; that dies should be fitted with porcelain inserts.

(379) Research Laboratories. S. Farnham and R. Potvin, *Trans. Can. Inst. Mining Met., 49,* 505-510 (1946). Paper discusses interesting findings in physical, metallurgy and chemical research laboratories of Metallgesellschaft (Frankfort, Germany) visited by authors in 1945. Work includes powder metallurgy.

(380) Principles of Powder Metallurgy. R. Girschig, *Soc. Ing. Civ. France Bull.,* No. 4/5, 39-41 (1946). The author discusses the principles of powder metallurgy and the properties of such products as self-lubricating bearings and sintered iron parts.

(381) Powdered Metals and the Engineer. H. W. Greenwood, *Inst. Engrs. & Shipbuilders in Scotland, Trans., 90,* No. 2, 101-25 (1946); Preparation of powders, processes of powder metallurgy; limitations and advantages; trained manpower problem is reviewed.

(382) Manufacture of Products from Powdered Metals. A. G. Haffenden, K. Heywood, R. J. Doyle, C. F. Austin and R. A. Bellamy, B.I.O.S. Final Report No. 908 (1946). Report on investigations at the German firms of Düsseldorfer Eisenhüttengesellschaft, Ratingen-Düsseldorf; Deutsche Eisenwerke A.-G., Mühlheim-Ruhr; Schwelmer Eisenwerke A.-G.; Sintermetallwerk A.-G., Krebsöge-Rhld.; and DVM-Sintermetallwerk, Neurod.

(383) Production Problems Studied by Metal Powder Association. *Iron Age, 157,* No. 25, 78-80 (1946). A review of the papers presented at the Spring meeting of the Metal Powder Association.

(384) Introduction to Session. H. E. Hall, *Proc. Second Annual Spring Meeting Metal Powder Assoc.,* New York, June 13, 1946. U. S. metal powder statistics are given.

(385) Review of German Science, 1939-1946. M. Hansen, F.I.A.T., Office of Military Government for Germany. Non-Ferrous Metallurgy, Part II (1946). This volume contains a chapter on "Powder Metallurgy and Sintered Metals" by H. Bernstorff, with appendices by G. Wassermann on special methods of producing sintered iron compacts, and by W. Dawihl on theory of sintered carbides.

(386) From Silicate Ceramics to Metal Ceramics. M. Hauser, *Elec. Eng. Abstracts, 49,* 86 (1946). *Cf: Schweiz. Bauztg., 125,* 282-284 (1945).

(387) Nonferrous Physical Metallurgy. R. Hultgren and E. R. Parker, *Mining and Met., 27,* No. 470, 93-100 (1946). On p. 97, the Powder Metallurgy Symposium of the Am. Inst. Mining Met. Engrs. held in Feb. 1945 is discussed.

(388) Development in Aircraft Engine Metallurgy 1920-1946. W. E. Jominy, *Metal Progress, 50,* No. 4, 687-690 (1946). Sintered bushings and new processes are discussed.

(389) British Powder Metallurgy. W. D. Jones, *Metal Ind. (London), 68,* No. 22, 431-41 (1946); *Powd. Met. Bull., 1,* No. 3, 48-49 (1946). Development, wartime applications, theoretical aspects. Lecture before Stevens Institute of Technology. Topics covered included copper-lead bearings, diamond tools, heavy alloys, and porous, self-lubricating carbide dies.

(390) Application of Powder Metallurgy to Engineering Products. J. A. Judd, *Eng. Material Processes, 4,* No. 10, 275 (1946). Examples illustrate advantages of powder metallurgy for products which cannot be made by other methods.

(391) The Use of Powder Metallurgy in Automobile Engineering. Part I — Ferrous Powder Metallurgy. J. A. Judd, *J. Inst. Automobile Engrs., 15,* No. 3, 83-100 (1946); *Powd. Met. Bull., 2,* No. 4, 90 (1947). The production of ferrous parts from sponge iron and cast iron powders is described. The importance of design aspects is stressed.

(392) **Long Sintering Reduces Porosity of Powder Metals.** G. F. Kappelt, *Metals Rev., 19,* No. 6, 4 (1946). Report is made on talk by F. C. Kelley in April at Buffalo.

(393) **Metal Powders: Britain and Here.** H. A. Knight, *Materials & Methods, 23,* No. 6, 1493 (1946). Sidelights of British powder metallurgy during war have been given by W. D. Jones at lecture at Stevens Inst. Technol.

(394) **Metal Powders.** H. Lacoste, *La Métallurgie, 78,* No. 11, 15-21 (1946). A review of the work of Kieffer and Hotop, Wulff, Jones, Williams and Price is presented.

(395) **Powder Metallurgy from the Engineer's Point of View.** J. F. Morden, *Coventry Eng. Soc., 27,* No. 6, 101 (1946). A lecture on principles of the method, properties, and performance.

(396) **Powder Metallurgy.** J. E. Newson, *Inst. Mech. Engrs. Proc. (London), 154,* No. 2, 208-213 (1946). Powder metallurgy makes possible articles of unique properties, and parts not readily obtained by melting.

(397) **Fritting of Metallic Substances.** M. Oswald, *Technique Moderne, 38,* 34, 65 (1946). Sintering of metallic substances, discussion of essentials. Comparison between metallic and clay ceramics.

(398) **Metal Powders.** D. B. Pall, *Interchem. Rev., 5,* 59-69 (1946). Review of various aspects of manufacture and applications of metal powders is presented.

(399) **Parts and Metal Forms.** F. P. Peters, *Materials & Methods, 23,* No. 1, 101-104 (1946). Developments during 1945. Section on powder metallurgy is included.

(400) **Rapid Progress Predicted for Steel Powder Metallurgy.** W. T. Rubin, *Metals Rev., 19,* No. 2, 2 (1946). Report on talk by C. C. Balke before Warren Chapter, Am. Soc. Metals, on Dec. 13, 1945.

(401) **The Future of Powder Metallurgy.** P. Schwarzkopf, *Powd. Met. Bull., 1,* No. 1, 3-5 (1946). Preprint of concluding chapter in *"Powder Metallurgy,"* Macmillan, New York, 1947.

(402) **Wear Resistant and Hot-Strength Metallic Materials.** P. Schwarzkopf, *Powd. Met. Bull., 1,* No. 6, 86-91 (1946). Powder Metallurgy is held as most promising method for their development. Only high melting materials can be expected to show satisfactory performance for wear resistant as well as for high temperature application. Cemented carbides and other hard metals, as developed for tool materials, have proved satisfactory in various applications requiring high resistance to wear.

(403) **Powder Metallurgy.** O. B. Smart, U. S. Dept. Comm. PB. 8141, 1946, 47 pp. Application and scope of powdered metals, production methods, engineering and physical characteristics are reviewed.

(404) **The Use of Powder Metallurgy in Automobile Engineering. Part II — Non-Ferrous Powder Metallurgy.** W. H. Tait, *J. Inst. Automobile Engrs., 15,* No. 3, 101-14 (1946). The production of bearings, bushings and thrust washers, clutches, and brake position plates is described.

(405) **Powder Metallurgy.** S. Tour, U. S. Dept. Comm. PB. 21828/1945, 10 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 25, 1573 (1946). The report describes Metallwerk Plansee, Reutte, and the work of R. Kieffer and W. Hotop.

(406) **Highlights of German Iron and Steel Production Technology.** P. M. Tyler, F.I.A.T. Rep t. No. 755 (1946). In a comprehensive account of the German iron and steel industry, the author includes a brief abstract from a report by G. J. Comstock on hard carbides and iron powder manufacture.

(407) **The Production of Powder Metallurgy Bodies.** Vereinigte Deutsche Metallwerke. F. D. Report No. 2535/46 (formerly H. E. C. 12385), 1946. A good general review article by O. Bruchhäuser in 1942.

(408) **Visit to Metallgesellschaft.** A. H. Waterfield, H. G. Cole, N. H. G. Daniels and R. L. Bickerdike, B. I. O. S. Final Rept. No. 504 (1946). Enumerates work undertaken in the metallurgical laboratories, including powder metallurgy.

(409) Powder Metallurgy. L. Weil, *Bull. l'Union Physicien, 40,* 49-59 (1946). A general review includes theory, powder production and characteristics, processing methods, and properties of the sintered products.

(410) Talks on Powder Metals. G. S. Young, *Metals Rev., 19,* No. 11, 8 (1946). Discussion of powder metallurgy methods given by D. B. Martin before meeting of the Kansas Chapter of the Am. Soc. Metals, Oct. 16, 1946.

(411) Principles and Possibilities of Powder Metallurgy. M. Zeicher, *Rev. Univ. Mines, 89,* No. 6, 234-43 (1946). Lecture given to Liège Soc. of Eng. covered a definition of sintering and the development of powder metals.

(412) Production and Uses of Iron and Other Powders. *Chem. Age (London), 56,* No. 1453, 641-42 (1947). A discussion of B.I.O.S. Report No. 706.

(413) Powder Metallurgy. *Echo mines & métallurgie,* No. 3391, 212-214 (1947). Mechanical and physico-chemical processes; compression and sintering of powders; Co and W carbides are discussed.

(414) Powder Metallurgy. *Engineer (London), 184,* No. 4773, 52-53; No. 4774, 72-73; No. 4775, 106-08; No. 4776, 119-21; No. 4777, 152-54; No. 4778, 165-68 (1947). Review of Symposium of Iron and Steel Institute, containing 28 papers, held before meeting on June 18-19, 1947, published as Special Report No. 38.

(415) Symposium on Powder Metallurgy. *Engineering, 163,* No. 4247, 530-31 (1947). The papers in the Iron and Steel Institute Special Report No. 38 are discussed.

(416) Symposium on Powder Metallurgy. Iron & Steel Inst. Special Report No. 38, London, 1947, 208 pp. Introductory. Preparation, properties, and testing of metal powders. Magnetic powders. Hard metal carbides. Porous metal components. Manufacture and properties of sintered components. (Individual papers are listed under their respective authors and classified according to subject matter).

(417) Stevens to Conduct Government Research in Powder Metallurgy. *Iron Age, 159,* No. 11, 131 (1947). Stevens Institute will test iron powders furnished by domestic producers to determine the factors affecting the physical properties.

(418) Expanding Metal Powder Use Stressed at Third Ann. Spring Meeting of Metal Powder Assoc., May 27, 1947. *Iron Age, 159,* No. 23, 84-86 (1947). Applications for metal powders, indicated in technical discussions, include stainless steel powder and production of steel-backed copper-lead bearings.

(419) Iron Powder Producer Suspends Production. *Iron Age, 160,* No. 8, 120 (1947). Metals Disintegrating Co. has decided to withdraw from the production of iron powders.

(420) British Progress in Powder Metallurgy. *Machinery (London) 71,* No. 1820, 295 (1947). The Special Report No. 38 of the Iron and Steel Institute is discussed.

(421) German Powder Plant. *Machinist (London), 90,* 1831 (1947). Describes an entire German carbide plant to be set up at Stevens Institute of Technology.

(422) German Metals Research. *Materials & Methods, 26,* No. 1, 127 (1947). Kaiser Wilhelm Institute for iron research was the major metals research organization. Powder metallurgy was among the subjects thoroughly investigated.

(423) Progress in Powder Metallurgy. *Materials & Methods, 26,* No. 2, 121-4 (1947). An abstract condensed from papers of the Metal Powder Assoc. presented at the Third Annual Spring Meeting at New York on May 27, 1947, is given. Topics covered are electronic components, steel back copper-lead bearings, production of metal parts and stainless steel powder.

(424) Powder Metallurgy. *Metal Ind. (London), 71,* No. 2, 27; No. 4, 70; No. 6, 109; No. 7, 149, 153 (1947). Review of papers before The Iron and Steel Institute's *Symposium on Powder Metallurgy* includes preparation, properties, testing of metal powders; magnetic powders; hard metal carbides.

(425) Development Difficulties in Powder Metallurgy. *Metal Treatment, 14,* No. 51, 133-34 (1947). Certain factors barring the way of universal acceptance of powder metallurgy methods are discussed.

(426) Powder Metallurgy. *Metallurgia, 36,* No. 214, 197-99 (1947). Review of papers before The Iron and Steel Institute's *Symposium on Powder Metallurgy* is presented.

(427) Products and Processes for the Non-Ferrous Industry. *Metals Rev., 20,* No. 2, 9-17 (1947). New powder metallurgy products have been recently announced by several companies.

(428) Study of Metal Powders. *Steel, 120,* No. 13, 90 (1947). Stevens Institute of Technology is to carry out research to improve metal powder techniques.

(429) Powdered Metal Parts and Applications. *Steel, 120,* No. 24, 106 (1947). Powder metal parts, their application and design styles; powder metal bearings are described in a brief note.

(430) Powder Metallurgy. E. Barry, *Metalen, 1,* No. 5, 77-84 (1947). (In English). Principles and applications of powder metallurgy during the war in England are described.

(431) High Production Methods for Metal Parts. D. Basch, U. S. Dept. Comm. PB. 68117/1940, 68 pp.; *Bibl. Scient. & Ind. Rept., 5,* No. 9, 781 (1947). This publication of General Electric Works Laboratories discusses among other methods also powder metallurgy.

(432) Some Aspects of German Powder Metallurgy. R. L. Bickerdike and N. H. G. Daniels, B.I.O.S. Final Rept. No. 78 (1947). A general review is based mainly on visits to the Deutsche Pulvermetallurgische Gesellschaft and the Metallwerk Plansee.

(433) Production Processes, Part 27 – Powder Metallurgy. R. W. Bolz, *Mach. Design, 19,* No. 9, 139-140 (1947). Typical average properties of metal powder parts from different metals and alloys, and treated in different ways, are analyzed.

(434) Use of Powder Metals. F. J. Borgstedt, *Metals Rev., 20,* No. 6, 45 (1947). A description is given of a lecture by H. W. Highriter before Des Moines Chapter of the Am. Soc. Metals on April 8, 1947.

(435) Latest Trends in Metal Powders. W. G. Cass, *Chem. Age (London), 56,* 5-10, 199-202 (1947). I. Historical background, recent developments. Thermal decomposion. Size of powder grains; inherent cohesive forces; hard refractories. Vibration to assist compacting; porous steel skeleton. II. Metallic hydrides, rare metal powders. Metallic cohesion.

(436) German Powder Metallurgy. G.J. Comstock, F.I.A.T. Rept. No. 772 (1947). Deals fully with carbides, iron powders, shell driving bands, and the various products of Metallwerk Plansee.

(437) Powder Metallurgy. G. J. Comstock, *Federal Sci. Progress, 1,* 34-35 (1947). Powder metallurgy processes, applications and limitations; wartime advances are discussed.

(438) New Developments in Powder Metallurgy. G. J. Comstock, *Iron Age, 159,* No. 21, 67 (1947). Advantage of precast alloy powders, hot-pressing, applications and developments are discussed.

(439) German Powder Metallurgy. G. J. Comstock, U. S. Dept. Comm. PB. 39354r (1947). Germans surmounted the difficulties associated with simultaneous application of great heat and pressure by using carefully weighted prepressed charges with a constant apparent density to control the final volume. Cu, Ag, Al powders for research were produced by the rotating disk method.

(440) Metal Powder Production. Deutsche Gold- und Silberscheideanstalt. F. D. Report No. 342/47 (1947). Contains the half-yearly report of the Degussa research departments for the period July-December, 1943. Of powder metallurgy interest are the manufacture of ball-milled beryllium powder (after leaching, Fe content 0.2%, but 15% Be lost); the manufacture of lighter flints from Th-Fe (high wear) and U-Fe (very brittle); the manufacture of hydrides of Ti, Zr and Th (impure raw materials and hydrogen absorption not improved by elevated pressures); and the manufacture of 2,900 kg. uranium ingots during 1943.

(441) Non-Ferrous Metals. J. L. Everhart, *Metals Rev., 20,* No. 2, 5 (1947). Includes short review of recent papers on powder metallurgy.

(442) Progress in Powder Metallurgy. H. Fischbeck and P. Schmidt, *Machinery (London), 71,* 295 (1947). A general review with reference notations.

(443) Production of Iron Powder by the Reduction of Rolling Mill Scale. Friedr. Krupp A. G., Essen. F. D. Report No. 1313/47 (1947). Contains a number of reports (dated 1937-43,) on preparation of vanadic acid from vanadium-containing slag; chromizing of steel with chromium chloride; recovery of tungsten from WC-Ni scrap, etc., but nothing on iron powder manufacture.

(444) Production of Sintered Alloys in 1936-43. Friedr. Krupp A. G., Essen. F. D. Report No. 1315/47 (1947). Summarizes research results on iron powders (minimum compacting pressure 60 tons/in.^{2} for a pressing density of 90% and sintering density of 95%); the manufacture of valve seats from iron, chromium and chromium carbide (no further details, but swelling occurred during sintering); the properties of sintered magnetic steels (Koerzit 500) as compared with those of cast steels.

(445) Manufacture of Sintered Alloys. Friedr. Krupp A. G., Essen. F. D. Report No. 1321/47 (1947). Brief progress reports on powder metallurgy work are included in eight quarterly reports of the Research Departments covering the period October, 1940, to September, 1942.

(446) Compressed Metal Powders. H. Godfroid, *Technique & Combat,* No. 37, 20-31 (1947). A general article referring to the production and properties of pressed articles.

(447) Powder Metallurgy. H. W. Greenwood, *Engineering, 163,* No. 4246, 492 (1947). Review of progress in Germany, United States and Great Britain is given; consideration of directions progress is to occur, and what problems await solution.

(448) Powder Metals To-day. H. W. Greenwood, *Machinery (Lloyd), 19,* No. 6, 80 (1947). Covers all essential problems encountered in manufacturing of powder metals.

(449) Metal Powders and Powder Metallurgy. H. W. Greenwood, Powder Metallurgy Ltd., Publ., London, 1947, 23 pp. Author emphasizes the need for careful size specification. Variations in size effect, porosity of the pressing, density, flow factor and voidage are discussed. Actual size is held important because powder metallurgy is concerned with surface phenomena.

(450) Powder Metallurgy: Potential Value to the Engineering Industry. H. W. Greenwood, *Metal Ind. (London), 71,* 519-520 (1947). Value of powder metallurgy as a means of solving problems in production of better wear resistant materials, and of metals and alloys capable of withstanding high temperature under load, is discussed.

(451) Baillieu Laboratory for Metallurgical Research. J. N. Greenwood, *Chem. Eng. Mining Rev., 39,* 325-327 (1947). The Baillieu Laboratory in University of Melbourne has been working on the physics of the metals Ti, Zr, V, Cr, Ta, Mo, W, notably by employing vacuum-sintering methods.

(452) Introduction to Session. H. E. Hall, Proc. Third Annual Spring Meeting Metal Powder Assoc., New York, May 27, 1947. U. S. iron powder statistics are given.

(453) Powder Metallurgy, Principles and Methods. H. H. Hausner, Chemical Publ. Co., Brooklyn, N.Y., 1947, 307 pp. Relationship between physical properties of metallic compact and variables of powder metallurgical process are graphically presented: powder particle size, compacting pressure, sintering time and temperature, atmosphere of heat treatment. Bibliography includes 1064 references.

(454) Powder Metallurgy Precision Parts. R. Hradecky and R. P. Seelig, *S. African Eng., 37,* No. 346, 13, 15 (1947). Postwar possibilities of new techniques are discussed; new products and new powder alloys and mixtures; electrical products, sintered carbides, stainless steel are cited.

(455) Recent Development in Powder Metallurgy. J. A. Judd, *Engineering Materials, 5,* No. 1, 6-14 (1947). Description of a press produced by F. J. Stokes Machine Co. and various sintering furnaces.

(456) Powder Metallurgy. E. Kirkendall, *Mining & Metallurgy, 28,* No. 487, 334 (1947). Report on activities of Am. Inst. Mining Met. Engrs., Inst. Met. Div., Powder Metallurgy Committee.

(457) German Powder Metals. H. A. Knight, *Materials & Methods, 25,* No. 2, 5 (1947). German methods of making powder metallurgy parts during the war as discussed by G. J. Comstock after visit in 1945.

(458) Powder Metallurgy. E. S. Kopecki, *Iron Age, 159,* No. 1, 99-100 (1947). Review of developments during 1947 include German wartime processes and especially precast powders.

(459) Metallic Filters and Alloy Welding Rod among Powder Metal Applications. F. Kristufek, *Metals Rev., 20,* No. 2, 29 (1947). A report is given on a talk by J. F. Sachse on application of powder metals at Nov. meeting of N. J. Chapter of the Am. Soc. Metals. Discussion also includes brazing and metal pigments.

(460) Notes on German Developments in Non-Carbide Powder Metallurgy (1939-1945). C. J. Leadbeater, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 191-202; *Met. Powd. Rept., 1,* No. 12, 184 (1947). A brief survey is made of the developments in the production of metal powders, the manufacture of sintered components, the types of equipment used in pressing and sintering, and the researches undertaken to study the mechanism of sintering.

(461) Pressing and Sintering. J. W. Lennox, *Machinery (London), 70,* 337-344 (1947). A review of the manufacture of typical parts by powder metallurgy.

(462) Metal Powders. L. Malpoker, *Metals Rev., 20,* No. 6, 35 (1947). Report on lecture by J. D. Shaw at Stevens Inst. Technol. in March 1947.

(463) Experimentation in Work of Yonkers Electro Metal Plant. F. McKnight and J. G. Cowley, *Modern Industrial Press, 9,* 20, 24, 26 (1947). American Electro Metal Corp. Laboratory is equipped with copies in miniature of all the plant's facilities including small presses and sintering furnaces.

(464) The Work of Skaupy on the Perfection of Sources of Light. A. R. Meyer, *Arch. Metallkunde, 1,* No. 7, 295-96 (1947). Review.

(465) Progress in Powder Metallurgy. E. R. Parker, *Mining World, 9,* No. 5, 25-26 (1947). Summarizes techniques and developments in powdered metals.

(466) Sintered Metal Powders. B. P. R. Parsons, E. H. Mehl, L. J. Grunspan, and B. D. Liddiard, B. I. O. S. Final Rept. No. 706, 150 pp.; *Met. Powd. Rept., 1,* No. 8, 115 (1947). A summarized report of the German industry overlapping with other reports of investigating teams.

(467) Research Organization for Powder Metallurgy. R. Reibel, *Métaux et Machines, 31,* No. 325, 405 (1947). Describes the organization and the program of research of Sintercast Corporation of America.

(468) Report on German Metal Powders. J. C. Richards, U. S. Dept. Commerce, PB. 63610/1946, 19 pp.; *Iron Age, 160,* No. 7, 132 (1947). Improvements over American and British practices noted by the investigators were especially in the sintering furnaces. Cf: B. I. O. S. Final Rept. 860 (1947).

(469) Progress in Powder Metallurgy. E. J. Sandford, *Metallurgia, 37,* No. 218, 95 (1947). Review of production and application development during 1947 is presented.

(470) Powder Metallurgy, Its Physics and Production. P. Schwarzkopf, Macmillan, New York, 1947, 379 pp. The book includes the main parts of processing of metal powders and products; theories on powder metallurgy, latest developments, future possibilities. Bibliography.

(471) Powder Metallurgy. P. Schwarzkopf, *Centenaire Congrès de l'Association des Ingénieurs.* Liége, 1947, Vol. III. Powder metallurgy is appraised as the logical choice of manufacturing method for the production of high-temperature materials.

(472) Postwar Activities of Metallwerk Plansee in Reutte (Tyrol). P. Schwarzkopf, *Powd. Met. Bull.*, *2*, No. 3, 52-53 (1947). New emergency applications for powder metal parts in Austria are described.

(473) Powder Metallurgy. W. H. Smith, *Wisconsin Engr.*, *51*, 6, 8, 9, 16, 30 (1947). Review.

(474) Powder Metallurgy. Reports of Watertown Arsenal Laboratory. A. Squire, Mapleton House, Brooklyn, N.Y., 1947. Nine reports are concerned with iron powders and compacts under varying conditions of state, treatment, processing, and their application in ordnance design.

(475) Hard Metal Research. Studiengesellschaft Hartmetall . F. D. Report No. 3981/47 (1947). Annual reports on hard metal research for 1940-43 are presented.

(476) Powder Metals. W. H. Tait, *Metal Ind., London, 70*, No. 2, 30-32; No. 3, 43-46 (1947). Improvement in technique and equipment for making more suitable powders, development of better presses and pressing techniques, more efficient furnaces are described.

(477) New Technique of Powder Metallurgy. G. Wassermann, *Metallforschung*, *2*, No. 5, 129-137 (1947). Parts of intricate design and considerable height or length are produced by special techniques such as advance pressing of small parts, then assembled and resintered, or filling powder into tubes, that are drawn. Die forging also discussed.

(478) Report of A. S. T. M. Committee B-9. *A.S.T.M. Preprint 15*, (1948), 2 pp. Reports progress on metal powders and products.

(479) Plans of the Sintering Plant Thyssen-Hamborn. F. D. Rept. No. 3544/48 (1948). (formerly H. E. C. 5769). Sundry drawings and a photograph are presented.

(480) Large Order for Tungsten Carbide. *Iron Age*, *162*, No. 10, 71 (1948). An order for one ton of sintered tungsten carbide was placed by a U. S. stoker manufacturer for surfacing the coal pulverizing parts in furnace stokers.

(481) Copper Powder. *Iron Age*, *162*, No. 10, 120 (1948). The Superior Metal Powders Corporation, Toledo, has taken up the manufacture of copper powder.

(482) Equipment for Production of Tungsten Carbide Parts. *Machinery (London)*, *72*, No. 1848, 398 (1948). A communication that a firm at Ilford, Essex, can supply entirely self-contained plants for producing tungsten carbide parts.

(483) New Development in Powder Metallurgy. *Machinery (London)*, *73*, No. 1868, 194 (1948). Dualloys Ltd., makers of plain bearings, have completed the installation of an up-to-date powder metallurgy plant. The products include self-lubricating bushes, gears, rotors, anti-friction strips.

(484) Motor Car Components Made by Powder Metallurgy. *Machinery (London)*, *73*, No. 1880, 639 (1948). Small sintered parts used in Ford, Mercury, and Lincoln cars include bushings and pistons in the shock absorber; bushings for generator and starter.

(485) Powder Metallurgy in Practice. *Machinery's Yellow Back Series No. 23.* The Machinery Publ. Co. Ltd. London, 1948, 56 pp. With the help of numerous illustrations, the design, pressing, sintering and coining of various parts is described; porous bearings and filters, cemented carbides included.

(486) Annual Engineering Review. *Materials & Methods*, *27*, No. 1, 87-106 (1948). Powder metals and metal powder parts are discussed on p. 97 and 103-104.

(487) Powder Metallurgy Digest. *Materials & Methods*, *27*, No. 3, 112-114 (1948). Covers several U. S. Dept. of Commerce, Office of Technical Service Publications: G. J. Comstock, PB 39354r, *German Powder Metallurgy*. H. L. Krebs, PB 78996, *German Methods for Iron Powder Cores*. PB 78259, *Cast Tungsten Carbides and Production of Tungsten-Free Hard Metals*.

(488) Powder Metallurgy: Report of International Symposium at Graz. *Metal Ind. (N. Y.)*, *73*, No. 5, 103-5; No. 6, 129-30. (1948). A review is given of the papers presented at First International Symposium of Powder Metallurgy held in Graz, Austria, on July 12-17.

(489) Powder Metallurgy, Seminar. *Mining & Metallurgy, 29,* No. 459, 186 (1948). Review of Spring Meeting of Am. Inst. Mining Met. Engrs. at New York.

(490) Powder Metallurgy Discussed. *Steel, 122,* No. 8, 158 (1948). Considerable discussion on powder metallurgy featured by Inst. of Mets. Div. of Am. Inst. of Mining and Met. Engrs. sessions in New York. Seminar was held on mechanism of sintering of two or more metals.

(491) Surface Chemistry in Metal Working Operations. *Steel, 123,* No. 23, 130, 133, 144, 146, 148, 154 (1948). Chemical aspects of surface reactions play an important part in wear and lubrication and in powder metallurgy and metal coatings.

(492) Powder Metallurgy (in Russian). M. Yu. Bal'shin. State Scientific Technical Publ. House, Moscow (Metallurgizdat), 1948, 332 pp. Topics treated in this text include theoretical bases; methods of production in U. S. S. R. and abroad; physical and chemical processes in the powder production; properties and applications of fabricated powder products.

(493) Sintering Processes of Powders (in Russian). A. S. Berezhnoi, *Ogneupory, 13,* No. 6, 256-66 (1948). A review of the literature, with bibliography.

(494) Metallurgy of Non-Ferrous Metals. H. Bernstorff. F.I.A.T. Rev. of German Science, Vol. 33. M. Hansen, Wiesbaden, 1948. A report is made of the development of powder metallurgy in Germany during the war.

(495) Molding and Sintering of Metal Powders. G. Blanc, *Fonderie,* No. 25, 1007-21 (1948). The review includes chemical, electrolytical and grinding processes; characteristics of metal powders from the viewpoint of structure and shape of grains; applications; photomicrographs; bibliography.

(496) Powder Metallurgy. A. M. Burghardt, *J. Chem. Education, 25,* No. 9, 517-20 (1948). A survey is made of the processes and applications of metal powders.

(497) Production of Articles by Means of Powder Metallurgy. A. G. Cassina, *Anal. Mec. Elect., 24,* No. 3, 125-35 (1948). Author discusses the two principal methods of pressing metal powders, and considers the various phases of the production, such as selection of materials, mixing, pressing, sintering, finishing.

(498) Where Does Powder Metallurgy Stand Today? H. R. Clauser, *Sci. American, 178,* 12 (1948). Review.

(499) German Powder Metallurgy. G.J. Comstock, U.S. Dept. Comm., PB. 39354r; *Materials & Methods, 27,* No. 3, 112 (1948). Germans worked along different lines than American metallurgists, especially in the manufacture of sintered carbide hard metals.

(500) Powder Metallurgy. F. W. Cousins, *Pract. Eng., 18,* 642, 679, 706; *19,* 45 (1948). Properties of metals, mechanical and chemical methods for manufacture, methods for determination of particle size, testing of powders and sintered parts, and magnets by powders are described.

(501) J. M. Dallavalle, *Micromeritics. The Technology of Fine Particles.* 2nd Ed., Pitman, New York, 555 pp. (1948). Dynamics of small particles; shape and size distribution; theory of sieving and grading of materials; packing; pressure; infiltration; capillarity are topics treated.

(502) Industrial Applications of Powder Metallurgy. R. Girschig, *Métallurgie et Construction Mécanique J., 80,* No. 11, 33-35, 37, 39 (1948). The physical bases of the sintering process, the preparation of powders, the construction of dies and the properties of sintered products are discussed.

(503) Powder Metallurgy – Its Widening Sphere of Usefulness. C. G. Goetzel, *Engineers Digest., 5,* No. 3, 96 (1948). Powder metallurgy has grown beyond the limited engineering field in pre-war years; a high demand, supported by basic economic factors, exists for continued growth and exploration of the field.

(504) High Temperature Materials by Powder Metallurgy. C. G. Goetzel, *Iron Age, 161,* No. 18, 78-81 (1948). The infiltration technique appears to be the most promising of powder metallurgy procedures. Author discusses the advantages

applied to the use of refractory metals and hard metallic compounds and projects his study into realm of oxides and ceramic compounds.

(505) Trends in Powder Metallurgy. C. G. Goetzel, *Mining and Met., 29,* No. 503, 606-9 (1948). A general survey of the present state and future prospects of powder metallurgy is presented.

(506) Powder Metallurgy Notes by J. Heuberger. R. A. Hetzig, *Metallurgia, 38,* No. 225, 169-71 (1948). English translation of paper in *Festskrift tillägnad,* J. Arvid Hedvall, Göteborg, 1948, pp. 241-9. Advantages of powder metallurgy methods; principles, equipment, sintering and materials are surveyed.

(507) Powder Metallurgy Has Some Limitations. T. J. Hughel and S. T. Ross, *Industry & Power, 54,* No. 2, 89-90 (1948). Although the powder method has made possible products that could not be obtained in desired form by other techniques, there are inherent physical limitations in that process; lack of fundamental knowledge concerning it is stressed.

(508) R. Kieffer and W. Hotop, *Pulvermetallurgie und Sinterwerkstoffe.* 2nd ed. Springer, Berlin, 1948, 412 pp. Powder metallurgy and sintered materials. The text includes principles and practices to be considered; raw materials and methods of operation used in powder metallurgy; scientific principles of powder metallurgy with specific attention to properties of sintered bodies; sintered metals and alloys; technique of sintering specific materials. Bibliographies.

(509) Powder Metallurgy. A. J. Langhammer, *Steel, 122,* No. 14, 86 (1948). A report is made on a lecture on the application of powder metallurgy to the manufacture of high-quality machine parts.

(510) Powder Metallurgy. C. H. Samans, *Metals Handbook,* Am. Soc. Metals, Cleveland, pp. 47-52 (1948). Typical products and processes, advantages and limitations, metal powders, and sintering conditions, are the main subjects treated.

(511) Forming without Cutting of Precision Working Parts. K. H. Sieker, *Arch. Metallkunde, 2,* No. 3, 87-93 (1948). Examples are given for die casting and pressing of metals, pressing of powdered metals, sectional drawing.

(512) Current Trends in Powder Metallurgy. W. F. Toerge, *Steel, 123,* No. 21, 73, 80, 111, 115 (1948). Mixing, pressing, and finishing practices; dies, metal-ceramic materials, production of powders are described. Process variables and their control are discussed.

(513) R. S. Young, *Cobalt.* (Am. Chem. Soc. Monograph 108) Reinhold, New York, 1948. Topics treated are metallurgy of Co, properties; Co in powder metallurgy (cemented carbides and permanent magnets); Co in ferrous alloys; electroplating; catalytic behavior of Co.

(514) Powder Metallurgy: Current Problems and Prospects. R. L. Ziegfeld, *Iron Age, 161,* No. 15, 72-74 (1948). Rapid expansion in powder metallurgy has resulted in many missteps. Article reviews increased use of powder metallurgy and suggests that wider dissemination of information and statistics of powder specifications and testing methods are essential for the development.

(515) Armour Coal, German Attempt to Utilize Powdered Coal as Material for Production of Sintered Compacts. *Engrs. Digest, 10,* No. 3, 80-2 (1949). Survey is based on original files of Krupp; from 1943 onwards, attempts were being made to apply powder metallurgical methods to pulverized coal, thus creating new material called sintered or armoured coal; claimed to possess unusual properties; they could be used for crucibles for sintering carbides.

(516) Brass Powder Parts in Toys. *Iron Age, 163,* No. 12, 71 (1949). C. Gilbert Co., manufacturer of toys, has found the use of pressed powder parts advantageous in several interesting applications.

(517) Metal Powder Meeting. *Iron Age, 163,* No. 15, 82-85 (1949). The Fifth Annual Meeting of the Metal Powder Association in Chicago is referred to.

(518) Powder Metallurgy In Germany. *Machinery Market,* No. 2535, 379-80, 391 (1949). Survey of progress from 1939 to 1945 is presented, covering generally, techniques employed in powder production, hard metal carbides, sintered iron and

steel, aluminum, magnesium and refractory metals; magnetic, electrical and high temperatures applications are briefly reported.

(519) Powder Metallurgy. *Metal Progress, 55,* No. 3, 323-4 (1949). Refers to the meeting in Pittsburgh of the Am. Soc. Testing Materials, Committee B-9.

(520) Powder Metallurgy. *Metal Progress, 55,* No. 3, 334-5 (1949). Refers to the reports on the San Francisco meeting of the Am. Inst. of Mining and Metallurgical Engrs. on Feb. 13, 1949.

(521) Powder Metallurgists Emphasize Production. *Metal Progress, 55,* No. 5, 660-1 (1949). Report of the Fifth Annual Meeting of the Metal Powder Assoc. in Chicago on April 5 and 6, 1949.

(522) Symposium on Physics of Powder Metallurgy. *Steel, 125,* No. 19, 127, 152, 155, 158 (1949). A review is presented of papers presented Aug. 24-26 at symposium sponsored by Sylvania Electric Products, Bayside, N.Y.

(523) Symposium on Physics of Powder Metallurgy. *Sylvania Technologist, 2,* No. 4, 16-18 (1949). A report is given on the symposium sponsored by Sylvania Electric Products on Aug. 24-26 at Bayside, N. Y.

(524) Powder Metallurgy. P. T. Arthur, *Pract. Eng., 20,* No. 513, 597-598 (1949). The historical development of the process, the preparation of powder, and pressing are reviewed. Some uses of powder metallurgy are described.

(525) A Survey of Powder Metallurgy Processes. L. Auguet and L. Duran, *Revista cienc. Applicada, 3,* 81-94, 168-85 (1949). General review.

(526) Powder Metallurgy. W. W. Beaver, *Metals Rev., 22,* No. 1, 5, 7, 8 (1949). A review of post-war manufacturing developments and new applications is given.

(527) Metals in Instruments. E. H. Bucknall, *Metal Ind., (London), 74,* No. 9, 163-5, 173; No. 10, 183-5; No. 11, 209-10 (1949). Problems regarding application of metals and alloys in instruments, and of manufacture of such alloys are reviewed; use of small castings; role of powder metallurgy in manufacture of small parts are discussed.

(528) Where Does Powder Metallurgy Stand Today? H. R. Clauser, *Materials & Methods, 29,* No. 3, 45-8 (1949). Problem of availability of high quality metal powders at reasonable cost, and examples of most frequently used ones are discussed, *e.g.*, copper, bronze, brass and iron; progress is reported in establishing standards and specifications; equipment and processing developments.

(529) Powder Metallurgy—Improved Technology Widens Application. G. J. Comstock, J. D. Shaw, C. L. Clark and W. V. Knopp, *Iron Age, 163,* No. 12, 72-4 (1949). Review of research and development work in last 12 months is presented; progress in hot-pressing of alloy powders, application of powder metallurgy to high temperature alloy field, and new projects and studies are main subjects discussed.

(530) Review of Major Reports at Powder Metallurgy Conference at Graz. J. Duflot, *Rev. mét., 46,* 544-48 (1949). A discussion of most important papers is given.

(531) Powder Metallurgy and the Future. T. C. DuMond, *Materials and Methods, 29,* No. 3, 43 (1949). Brief survey.

(532) A Survey of Powder Metallurgy Processes — I — III. L. A. Durán, *Rev. cienc. applicada, 3,* No. 2, 81-94; No. 3, 168-85; No. 4, 255-68 (1949). Description of various processes, powder characteristics and properties is given.

(533) Powder Metallurgy. G. Fitzgerald, *Electronic Eng., 21,* No. 253, 87-90 (1949). A survey is given of modern methods of producing metallic masses by sintering; included are processes for reduction of substance to powder form and then sintering; control of grain growth; production of single crystals; molding powdered metals; applications of powder metallurgy in industry.

(534) Increasing Uses of Powdered Metal Parts. J. Geschelin, *Automotive Inds., 101,* No. 9, 27, 64, 67 (1949). Amplex Mfg. Co. produces 229 Oilite bearings and machine parts of oil cushion type for Chrysler; piston made from powdered iron and used in direct acting shock absorbers is excellent example of advantages offered by powder metallurgy production; other parts shown; large potentialities in field suggested.

(535) Powder Metallurgy and Heat-Resisting Alloys. H. W. Greenwood, *Engineer, 187,* No. 4862, 349-51 (1949). A survey is presented of main lines of development of heat resistant alloys, nature of problems that have arisen, means by which they have been solved and pointers provided to further progress; what powder metallurgy can do and what possibilities it offers is also discussed.

(536) Problems of Pressing Metal Powders. H. W. Greenwood, *Machinery (London), 74,* No. 1909, 696-7 (1949). General observations, and report of recent developments are given; methods now used to obtain higher densities are presented as typical examples of progress made; work hardening of powders; infiltration techniques are described.

(537) Powder Metallurgy. H. W. Greenwood, *Metal Ind., (London), 75,* No. 2, 32-33 (1949). A survey of advances made from pre-war practice is given; experimental work on production of "sweat-cooled" units; production of carbide bits; application of cementation methods to production of parts with high physical properties; possibility of producing components weighing 200 lb. and up to 20 in. in diameter.

(538) Powder Metallurgy in Germany During War. R. A. Hetzig, *Engineering, 168,* No. 4353, 14 (1949). Review of reports published by H. M. Stationery Office, London.

(539) Research in Non-Ferrous Field at General Electric Co., Ltd. I. Jenkins, *Metal Treatment, 16,* No. 57, 49-57 (1949). Laboratory facilities; sintering furnaces; the Wetherill-type magnetic separator; X-ray analysis apparatus are described.

(540) History and Theoretical Foundation of Powder Metallurgy. R. Kieffer, *Einführung in die Pulvermetallurgie.* Technische Hochschule, Graz, 1949, pp. 7-33. General science of sintering and art of pressing of powders are presented.

(541) Production and Properties of Novel Types of Sintered Alloys, Produced by Infiltration Process. R. Kieffer and F. Benesovsky, *Berg- und Hüttenmännische Monatshefte, 94,* No. 8/9, 284-94 (1949). Principles of process of immersing porous compacts in metallic melts are discussed; suitable alloy combinations, iron alloys; mercury-bearing alloys; heat and oxidation resisting alloys; and carbides are included in the survey.

(542) The History of Metallwerk Plansee in Reutte, Tyrol. R. Kieffer and F. Benesovsky, *Blätter für Technikgeschichte,* No. 11, 82-91 (1949). A condensed history of the development of the factory.

(543) Planning of Engineering Research. W. E. Kingston, *Metal Progress, 56,* No. 3, 341-43 (1949). A discussion is presented of organizing research at Sylvania Electric Products, Inc. Description is given of project reviews and work outlines, and the advantages of planned research are listed. Covers powder metallurgy projects.

(544) The Physics of Powder Metallurgy. F. V. Lenel, *Metal Progress, 56,* No. 4, 515, 570, 572, 574, 576, 578, 580 (1949). A report is made on the symposium organized by Metallurgical Laboratories of Sylvania Electric Products, and held in Bayside, N.Y., Aug. 24-26, 1949.

(545) Powder Metallurgy. A. Michel, *La Documentation Métallurgique,* No. 1, 3-13 (1949). The first issue of this new digest of metallurgical literature begins with a well-written review of powder metallurgy.

(546) Powder Metallurgy. J. F. Mills, *Mine and Quarry Eng., 15,* No. 6, 175-81 (1949). Historical outline, preparing metal powders, methods of reduction of oxides and ores, compacting and sintering, and products are discussed.

(547) Powder Metallurgy. T. C. N'Guyen, *Ann. Radioélectricité, 4,* 233-48 (1949). The general principles, industrial possibilities, and the manufacture of powders are discussed.

(548) Instruments, Progress and Productivity. D. A. Oliver, *Trans. Soc. Instrument Technology, 1,* No. 5, 2-7 (1949). Development of galvanometer into modern moving coil meter; British instrument industry and objectives of Soc. Instrument Technology; discussion of three production methods for instrument parts, namely, powder metallurgy, precision casting and new method which con-

sists of diffusing chromium into nearly pure iron and then producing stainless steel shell by leaching out body of component with nitric acid.

(549) False Teeth Made in Sintered Molds. F. P. Peters, *Materials & Methods, 29,* No. 4, 170 (1949). The editorial director's gossip column reports that metal powder molds for plastic false teeth are made by the dentists themselves.

(550) Powder Metallurgy. H. Schrader and H. Fahlenbrach, *Z. Ver. deut. Ing., 91,* No. 19, 485-92 (1949). Principles, prospects and future problems; review of major materials; processes, theories, advantages and disadvantages are reviewed.

(551) Recent Developments in Powder Metallurgy. I. P. Schwarzkopf, *Powd. Met. Bull., 4,* No. 2, 28-56 (1949). Subjects treated include characteristics of metal powders; preparation; treatment of powders, sintering, subsequent treatments; and interrelations between powder characteristics and compacting and sintering conditions.

(552) Recent Developments in Powder Metallurgy. II. P. Schwarzkopf, *Powd. Met. Bull., 4,* No. 3, 64-111 (1949). A comprehensive review arranged under the following headings: ferrous dense products, non-ferrous dense products, porous products, refractory metals, hard metals, diamond tools, electric contact and resistor materials, magnetic materials, and friction parts. An extensive bibliography is included.

(553) Powder Metallurgy. N. Thien-Chi, *Annales de Radio-Électricité, 4,* No. 17, 233-48 (1949). Historical review and discussion of possibilities and practical applications of powder metallurgy is presented; fabrication of powders, description of laboratory experiments on Ni, Cu-Ni, refractory pseudo-alloys of W or Mo with Cu or Ag, W-Ni-Cu alloys, Fe-Ni-Co alloys for sealing to glass, and sintered nickel compacts for oxide coated cathodes in electron tubes are discussed.

(554) Powder Metallurgy. W. S. White, *Can. Metals Met. Inds., 12,* No. 2, 30 (1949). Refers to a lecture given by O. W. Ellis to the Montreal Chapter of the Am. Soc. Metals.

(555) Powder Metallurgy No Panacea. R. L. Ziegfeld and K. H. Röll, *Iron Age, 163,* No. 12, 68-71 (1949). Before accepting technique, the following basic factors should be investigated by manufacturers: dimensional tolerances to be met and maintained, physical and mechanical properties of powder metallurgy parts, and problem of production costs; progress of powder metallurgy is discussed; necessity for formulation of standards is pointed out.

(556) Powder Metallurgy – A Challenge. R. L. Ziegfeld and K. H. Roll, *Modern Machine Shop, 22,* No. 7, 72-86 (1949). A general review deals with the process, tolerances, post-war developments, powder position, hot-pressing and standardization. The function of the Metal Powder Association is discussed.

(557) Metalloceramics. F. Skaupy, *Metallkeramik,* 4th ed., 267 pp. Verlag Chemie, Weinheim/Bergstrasse, 1950. Completely revised edition, with latest references considered. Patent references of 3rd ed. (1943)are considerably augmented.

(558) The Preparation of Alloy Products from Fully Alloyed Powders. G. J. Comstock and J. D. Shaw, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, Chap. 22, pp. 372-388, 1951. Methods for producing alloy powders are discussed, and a few selected data on the properties of compacts made from such powders are given.

3. INDUSTRIAL, DESIGN, AND ECONOMIC ASPECTS

(559) The Economic Uses of Cemented Carbide and Other High-Duty Alloy Tools. E. W. Field and J. H. Garnett, *Machinery (London), 41,* 61-65, 97-100 (1932). Cost of tooling with cemented carbides is reviewed.

(560) Powdered Metals from Designer's Point of View. *Product Eng., 4,* No. 1, 9 (1933). Particular reference is made to suitability for bearings.

(561) Economic Importance of Hard Metals. K. Becker, *Metallwirtschaft, 17,* No. 20, 553-555 (1938). Properties and uses of hard metal cutting alloys are discussed in the light of industrial and economic considerations.

(562) The Boundaries of Economy During Turning of Steel with Hard Metal Tools. W. Dawihl, *Maschinenbau–Der Betrieb, 17,* No. 19, 511-13 (1938). Time limit of the operative use of hard metal tools, ascertainment of the economical cutting speeds, and costs of removal by cutting are discussed.

(563) Powdered Iron. Industrial Bull. No. 150, 1 of Arthur D. Little Inc. (1939). Applications and commercial considerations are reviewed.

(564) Problem of Producing Low-Cost Iron Powder Begging Solution. A. T. Fellows, *Steel, 105,* No. 16, 128 (1939). The sources of Fe powder are limited in the U. S., with electrolytic Fe available only in small quantities. Carbonyl iron in Germany and sponge iron in Sweden have high prices on the U.S. market.

(565) Powder Metallurgy. C. Hardy, *J. Inst. Metals, 6,* No. 7, 302 (1939). Discussion of the commercial importance of the field is presented in a letter to the editor.

(566) Demand for Iron Powder Awaits Realization of Economic Value. R. H. Montgomery, *Steel, 105,* No. 16, 128 (1939). The new product will be acceptable to the trade as soon as the industry learns the economic value of powdered sponge iron and to make less costly dies.

(567) Powdered Iron; Uses and Manufacturing Methods. *Engineer (London), 169,* 25 (1940). Sponge iron possibilities. An industrial appraisal.

(568) Gear Powders. *Engineer (London), 169,* 239 (1940). The production of metal powder parts is facilitated by using special fully automatic presses exclusively for specific parts.

(569) The Iron Powder Situation. A. T. Fellows, *Metals & Alloys, 12,* No. 3, 288-291 (1940). A demand for powdered iron in excess of the presently available sponge iron from Sweden, whose import may be affected by the war, leads to a review of the potential domestic iron powder producers.

(570) Design of Parts Made of Sintered Metals. G. Z. Griswold, *Machine Design, 12,* 41-43, 83 (1940). Industrial design possibilities of powder metallurgy are discussed.

(571) Problems Connected with the Fabrication of Metal Parts from Powders. H. E. Hall, *Metal Progress, 38,* No. 4, 531-32 (1940). General problems, mostly economical, are considered. Cost of raw material and operations *vs.* quality of end product is considered.

(572) Limitations of Powder Metallurgy. E. S. Patch, *Iron Age, 146,* No. 25, 31-34 (1940). They are based on three main factors, materials, men and machines. Fundamentals of materials, design and costs are presented.

(573) Designing for Powder Metallurgy. F. P. Peters, *Metals & Alloys, 12,* No. 5, 613, 648 (1940). An editorial on the commercial aspects of the art.

(574) Metal Powder – Industry's New Ally. *Modern Industry, 2,* No. 3, 55-59 (1941). Lower costs and new materials are discussed.

(575) Designs for Speedier Production. *Product Eng., 12,* No. 4, 153 (1941). Pressing of parts from metal powders (p. 192); discussion of general design aspects; formability; size and shape limitations; dimensional tolerances.

(576) Parts Pressed from Metal Powders. *Product Eng., 12,* No. 4, 192-93; No. 9, 496-500 (1941). Designs for speedier production are discussed.

(577) Powder Metallurgy. F. P. Peters, *Metals & Alloys, 14,* No. 4, 482-483 (1941). A section on the subject is included in article entitled "Faster Production."

(578) Designing Powdered Metals Machine Parts. R. P. Seelig and E. C. Gordon, *Machine Design, 13,* No. 4, 42-44 (1941). Substitute for expensive machining, powder metallurgy part size determines tolerances; properties of parts still largely unexplored; tapers and other expedients for ejection; rules for changes in cross section are given.

(579) War's Effect on Tungsten. C. H. Segerstrom, *Mining Congr. J., 27,* No. 2, 38-40 (1941). Economical and statistical review of the subject is given.

(580) Iron Powder Situation. L. A. Wilson, *Metals & Alloys, 13,* No. 1, 51-2 (1941). Discussion of A. T. Fellows' article in *Metals & Alloys, 12,* No. 3, 288-291 (1940). Sponge iron from ores in U. S. A. is claimed to be as good as that from Swedish ore.

(581) Powdered Metals in Machine Design. *Machinery (London), 61,* No. 1577, 737-40 (1942). Some properties and applications of powdered metal parts are given. Parts made from iron and application of same, pressures used in briquetting powders, and powdered metals in bearings are reviewed.

(582) Powdered Metals in Machine Design. *Machinery (N.Y.), 48,* No. 12, 111-118; *49,* No. 1, 148-52 (1942). Parts from compressed metal powder, bearings, oil-impregnation, gears are reviewed. Possibilities and limitations are discussed.

(583) Condensed Review of Some Recently Developed Materials. *Machinery (N.Y.), 49,* No. 2, 174-84 (1942). Alphabetical listing by trade names of various materials, including powdered iron materials.

(584) Industrial Powder Metallurgy. P. R. Kalischer, *Iron Age, 149,* No. 6, 41-6; No. 7, 46-51 (1942). Techniques and procedures, manufacture, practical applications are discussed in a detailed review.

(585) What Powder Metallurgy Offers to the Alert Engineer and Designer. *Elec. Mfg., 31,* No. 6, 81-84, 154, 156, 158, 160, 162, 164, 166, 168 (1943). Some parts now made with powdered metals are listed. Production methods are discussed.

(586) Powdered Metals in Machine Design. *Machinery (London), 62,* No. 1578, 1-4 (1943). Processing of parts; procedure in making babbitted main and connecting rod bearings, gears.

(587) Designing Powder Metal Machine Parts. C. Carmichael, *Machine Design, 15,* No. 11, 124-7, 180 (1943). Review of factors which influence advantageous use of powder metal parts in machine design.

(588) Is Powder Metallurgy Costly? H. W. Greenwood, *Metal Ind. (London), 63,* No. 14, 213-14 (1943). Factual data are given on its economy.

(589) Powder Metallurgy Production. R. P. Koehring, *Tool Engr., 12,* No. 11, 105-6, 148, 150, 152, 154 (1943). A description is given of briquetting and sintering processes in the production of oil pump gears, self-lubricating bearings, irregularly contoured cams and Diesel injection filters and manufacture of Babbitt bearings at Moraine Products Div., General Motors Corp. Technical and economic advantages of the methods employed are discussed.

(590) Swedish Sponge Iron. E. Améen, *Iron Age, 153,* No. 3, 55-59; No. 4, 56-65 (1944). Operative data, early experiments, reliability of process, steel making practice, cost of production analyzed.

(591) Design of Powdered Metal Parts. W. H. Arata, *Product. Engr., 15,* 561-64 (1944). Advantages, limitations, design data, general physical properties and typical applications of powdered metal parts are presented as a guide in the design of machine components.

(592) How a Solid Metal Fabricator Views Powder Metallurgy. D. K. Crampton, *Iron Age, 153,* No. 22, 135-137 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Powder metallurgy not seen as serious threat of competition to solid copper manufacturers.

(593) What Brass Powder Parts Offer the Designer. E. H. Kelton, *Machine Design, 16,* 129-132 (1944). Machine parts made of sintered brass powder are described as being produced at considerable savings.

(594) Technical Requirements of Metal Powders. E. S. Patch, *Iron Age, 153,* No. 22, 58 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Industrial and economic aspects of parts production are discussed, with special emphasis on control of manufacture.

(595) Introduction to Powder Molding. I. D. Press, *Tool & Die J., 9,* No. 10, 78-85 (1944). Description and chart of presses and dies. Die and product design considerations; lateral flow and powder distribution; simplicity *vs.* cost, press selection.

(596) Critical Summary of Powder Metallurgy and Its Application in Ordnance Design. A. Squire, *Watertown Ars. Lab. Rept. WAL 671/15* (Aug. 21, 1944) 28 pp.; U. S. Dept. Comm. PB. 49080/1945. Object of the report is *(1)* to evaluate the materials which can be produced by powder metallurgy, *(2)* to enumerate the factors which determine the suitability and application of the method, and *(3)* to discuss those features which are generally considered essential to the economic production of metal powder parts.

(597) Design of Powder Metallurgy Parts. M. T. Victor and C. A. Sorg, *Metals & Alloys, 19,* No. 3, 584-89 (1944). Practical information on designing of parts made by powder metallurgy. Parts which should and should not be made by powder metallurgy, limitations of the process in general, and of size and shape of pieces and dies, specifically, are reviewed.

(598) Production and Design Limitations for Metal Powder Products. *Iron and Coal Trades Rev., 150,* No. 4026, 625-6 (1945). Report of Powder Metallurgy Conference in New York under the auspices of the American Institute of Mining and Metallurgical Engineers, February 1944. (Papers are individually abstracted in this bibliography.)

(599) Price of Metal Powders Used in Electronics Field No Object. C. Hardy, *Steel, 116,* No. 1, 278-279 (1945). Purity of powders important for application in electrical field: electronics, x-ray, radio, radar.

(600) Cemented Carbide Reduces Cost of Cold Nosing Shells. C. W. Hinman, *Steel Processing, 31,* No. 8, 501-02 (1945). Using dies lined with cemented carbide reduces the die cost from 75 to 90%, and is lowering maintenance costs.

(601) Powdered Metal Points the Way to Machine Building Economics. A. J. Langhammer, *Machinery (N. Y.), 51,* No. 8, 152-161 (1945); *La Machine Moderne, 39,* No. 432, 61-66 (1945). Products weighing as much as 100 lbs. can be made economically by this process. Properties of self-lubricating bearings are given. Production of sintered iron parts by Chrysler is described.

(602) Powder Metal Machine Parts. A. J. Langhammer, *Product Eng., 16,* No. 12, 877-879 (1945). Characteristics of powdered metals used in machine parts; design considerations such as die shape, wall thickness, tolerances and control of hardness or porosity are discussed.

(603) Powder Metallurgy As Applied to Machine Parts. A. J. Langhammer, *Trans. Am. Inst. Mining Met. Engrs., 161,* 531-534 (1945). Design of parts, advantages of powder metallurgy, and limitations are discussed.

(604) Powdered Metal Machine Parts Break Serious Production Bottlenecks. E. W. Marshall, *Metals Rev., 18,* No. 6, 3 (1945). Ottawa Valley Chapter, Am. Soc. Metals, was addressed by G. E. Platzer of Amplex Div., Chrysler Corp., on powder metallurgy machine parts.

(605) Reducing Costs with Powder Metallurgy. C. T. Pearson, *Production Eng. & Management, 16,* No. 6, 89-92 (1945). New combinations of elements broaden the production of pressure-formed parts and afford additional opportunities for savings in product costs.

(606) Design Factors for the Metal Forms with Which Powder Metallurgy May Compete. F. P. Peters, *Trans. Am. Inst. Mining Met. Engrs., 161,* 527-530 (1945). Sand casting, die casting, permanent-mold casting, precision casting, machined bar stock, cold heading, drop forging, stamping and drawing, constitute a strong competitive field for powder metallurgy.

(607) Metal Powders – Grades and Data. J. F. Sachse, *Buyer's Guide of the Metal Industries,* Am. Society for Metals, 1945, p. 73. Analysis of different commercial powders is given.

(608) Processing Techniques Affect Design of Powder Metal Parts. P. Schwarzkopf, *Am. Machinist, 89,* No. 17, 118-21 (1945). Discussion of limitations imposed by peculiar characteristics of powder metallurgy processes; compacting

and ejection difficulties considered in relation to size and shape of article, length to cross-section, resistance of powders to plastic flow and requirements of strength and ductility; effect of design of powder metallurgy parts on die design and processing techniques.

(609) Powder Metallurgy Parts. R. P. Seelig, *Metals & Alloys, 21,* No. 1, 101 (1945). Part of "Design Selection of Parts and Fabrication Methods" – a series of articles. New developments during 1944 include self-lubricating bearings from aluminum, pole pieces, sintered machine parts.

(610) Mechanical Parts Made from Powdered Metals. R. P. Seelig, *Steel, 117,* No. 21, 116-9, 156, 158, 163-4, 166, 168, 170, 172, 174, 176, 178 (1945). Analysis of possibilities and limitations of powder metallurgy as means of producing machine parts; equipment and processing outlook and past applications in this field reviewed. Design features discussed.

(611) Symposium on Production and Design Limitations and Possibilities for Powder Metallurgy Parts. *Metallurgia, 33,* 154-156 (1946). Deals more particularly with design factors in powder metallurgy.

(612) Designing Powder Metal Parts. *Steel, 118,* No. 22, 108-110, 156-159 (1946). Abstract from Durex Engineering Manual published by Moraine Products Div., General Motors Corp. If the limitations of powder metal briquetting are understood, parts can be designed accordingly and full advantage taken of the savings this production method has to offer.

(613) Swedish Sponge Iron Powder Now Available at Lower Prices. J. Anthony, *Iron Age, 158,* No. 13, 114 (1946). Sponge iron plant at Höganas produces 8000 tons annually. Willing to expand facilities to meet increased demand.

(614) Powder Metallurgy Offers New Approach to Lower Costs. J. L. Bonanno, *Production Eng. & Management, 18,* No. 6, 51-54 (1946). Product improvement and reduced processing costs have resulted from an extensive use of powder metallurgy for mass production of small parts by Lionel Corp.

(615) Powdered Metal versus Other High Production Methods. H. Chase, *Materials & Methods, 24,* No. 2, 363-369 (1946). When selecting a method for the production of small parts, there are some factors which point to one way as a "natural" or to its elimination. Points of comparison include materials available, relative costs and properties; size and weight limitations; shape limitations; rates of production; tooling costs; scrap losses; dimensional limits; smoothness of surface; conclusions.

(616) Considerations in Designing Parts for Powder Metallurgy. J. Donahue, *Mechanical Eng., 68,* No. 11, 949-52 (1946); *Eng. Digest, 8,* No. 3, 85-88 (1947). Consideration of forming sintered metal parts, with particular reference to the dimensional accuracy and stability obtainable.

(617) Fundamental Facts about Iron Powder Costs. B. T. DuPont, *Proc. Second Ann. Spring Meeting Metal Powder Assoc.,* New York, June 13, 1946, pp. 54-59. Economies of iron powder production are evaluated.

(618) The Use of Powder Metallurgy in Automobile Engineering. J. A. Judd, *J. Inst. Automobile Engrs., 15,* No. 3, 83-100 (1946); *Powd. Met. Bull., 2,* No. 4, 90 (1947). The author believes that the future of ferrous powder metallurgy lies in the hands of the designer, who has to design parts for this process.

(619) Iron Powder at Logical Source. H. A. Knight, *Materials & Methods, 24,* No. 4, 815 (1946). New plant in Northern Minnesota will turn out 5 tons of Fe powder per day.

(620) The Statistical Approach in Industrial Research. A. Lesser, Jr., *Iron Age, 158,* No. 8, 50-55 (1946). Based on statistical experiments conducted during the war with regard to quality control and inspection the author outlines a procedure equally satisfactory for post-war industrial research. Data obtained from work in field of powder metallurgy at Stevens Institute of Technology.

(621) Editors View of Ferrous Powder Metallurgy. F. P. Peters, *Proc. Sec. Ann. Spring Meeting Metal Powder Assoc.,* New York, June 13, 1946, p. 80-85. Problems of quality, price and cooperation of various production branches are discussed.

(622) Design of Powder Metal Parts. M. T. Victor and C. A. Sorg, *Western Machinery & Steel World, 37,* No. 5, 248-51 (1946). Powder Metallurgy fundamentals and their influence on design of parts. Outline of limiting factors applying to all shapes of powder metallurgy parts.

(623) Industrial Iron Powder Metallurgy. *Iron & Steel (London), 20,* 108-109 (1947). Economies in the production of small parts are reviewed.

(624) Rapid Method of Producing Powder Metallurgical Aircraft Parts. *Machinery (N.Y.), 54,* No. 4, 146 (1947). Description of how grooving operations on powder metal aircraft parts are being performed four times faster by conversion of a standard Walker-Turner radial cut-off machine to an automatic grooving unit.

(625) Man Hour Savings Ratio on Powder Metal Jobs. G. W. Birdsall, *Metals Rev., 20,* No. 6, 53 (1947). A wealth of information on the economies of powder metals was presented by H. W. Highriter on April 1, 1947 before the Louisville Chapter of the Am. Soc. Metals.

(626) Production Processes, Part XXVII: Powder Metallurgy. R. W. Bolz, *Mach. Designs, 19,* No. 9, 139-140 (1947). Diagrams of preferred die designs are discussed from the production angle. Average physical properties of metal parts are summarized.

(627) Development in Metal Powders. R. W. Deutscher, *Inst. Production Engrs., 26,* No. 5, 137-138 (1947). Survey is presented of how developments in powder metallurgy during last 10 years have influenced production and affected the work of the engineer.

(628) New Developments in the Production of Metal Powder Parts. E. E. Ensign, *Proc. Third Ann. Meeting Metal Powder Assoc.,* New York, May 27, 1947, pp. 14-20; *Automotive Inds., 97,* No. 4, 30-33 (1947). A detailed description is given of the machinery in the powder metal parts production department of the Ford Motor Company.

(629) Economy of Production of Structural Parts by Powder Metallurgy. H. W. Fischer and R. P. Seelig, *Powd. Met. Bull., 2,* No. 6, pp. 128-134 (1947). Direct costs include raw material, molding, sintering, coining, annealing, finishing and inspection; overhead costs are discussed.

(630) Report on Widia Factory. Friedr. Krupp A. G., Essen. F. D. Reports. No. 1325/47 and 1326/47 (1947). Company reports of 1942-43, with one chapter dealing with the Widia department operations.

(631) Survey on Production and Properties of Hard Metals for Tools. Friedr. Krupp A. G., Essen. F. D. Report. No. 4147/47 (1947). A general outline of the changes in production methods made by Krupp during the period 1932-44, with details of floor space in the different factories and flow-sheets for the different qualities.

(632) The Economy of Using Hard Metal Instead of High Speed Steel. Friedr. Krupp A. G., Essen. F. D. Report. No. 4183/47 (1947). Cutting speeds and waste from regrinding were determined for carbide tools and high speed steel tools on three qualities of cast iron. Waste for equal quantities of turnings was 14-44 times greater with high speed steel than with hard metal. The latter compared also more favorably as regards expenditure of foreign exchange.

(633) Powder Metallurgy. H. W. Greenwood, *Engineer, 183,* No. 4766, 471-472 (1947). Discussion of mechanical properties and the design limitations of form and size of compacts is presented.

(634) Cost Calculation in the Production of Powder Metallurgy Parts. H. H. Hausner, *Proc. Third Ann. Spring Meeting Metal Powder Assoc.,* New York, May 27, 1947, pp. 21-30 (1947). Some fundamental calculations which may be applied in a general way are presented.

(635) Problems of Powder Metallurgy. A. Martigny, *Usine nouvelle, 3,* No. 34, 12-21 (1947); *Met. Abstracts, 15,* 106 (1947). Consideration of the economy of the production of parts for machines with regard to other methods.

(636) Static Hazard in Metal Powder Industries. G. Morris, *Engineering, 164,* No. 4251, 49-50; No. 4252, 73-74 (1947). Review of conditions for generation of electro-static charges in various industries including metal powder industry.

(637) Powder Metallurgy. Process or Product? E. S. Patch, *Iron Age, 159,* No. 2, 64-67 (1947). Powder metallurgy should be considered as a process rather than a product, and must be established as a production line factor, if powder metallurgy industry is to expand to its potential capacity.

(638) Refractory Metal Industry Since 1914. A. L. Percy, *Metal Progress, 52,* No. 4, 600-602 (1947). Production of refractory metals started in a small way in the Chicago area. Matching the path of demands, volume production that once was in ounces now is measured in tons.

(639) Economics of Iron Powder Manufacture. J. F. Sachse, *Iron Age, 159,* No. 21, 62-63 (1947). Analysis of factors influencing economy of iron and steel industry as compared with iron powder industry. Existing and projected iron powder production capacity is discussed.

(640) How to Evaluate Engineering Properties of Iron Powder Parts. A. Squire, *Materials & Methods, 25,* No. 6, 89-93 (1947). Quality characteristics of powder metallurgy compacts, influence of materials, processing conditions on uniformity of properties; interrelation of quality characteristics is shown.

(641) Hard Metal Plant. Studiengesellschaft Hartmetall. F. D. Report. No. 3746/47 (1947). A detailed cost estimate for erecting a hard metal plant in Milan was made in 1936.

(642) Carbide Plant. Studiengesellschaft Hartmetall. F. D. Report. No. 3763/47 (1947). Detailed estimate for cost of erecting and operating a quarter ton per month carbide plant is given in this report (1937).

(643) Carbide Manufacture. Studiengesellschaft Hartmetall. F. D. Report. No. 3770/47 (1947). Safety measures in carbide manufacture are discussed in this report dating from 1937.

(644) Hard Metal. Studiengesellschaft Hartmetall. F. D. Report. No. 3782/47 (1947). An economic comparison of hard metal and high-speed steel, dating from 1938.

(645) Economic Importance of Sintered Carbides. J. Witthoff, *Arch. Metallkunde, 1,* No. 7/8, 316 (1947). Author attempts to calculate the advantages gained by using carbide tools in preference to steel tools; time is saved through higher cutting speeds and longer life, better use of the machines.

(646) Making Wheels for Toy Locomotives. *Machinery (London), 72,* No. 1860, 735-6 (1948). Powder pressing operations on standard Stokes presses at Lionel Corp., Irvington, N.J., and press data are presented; use of carbide dies, and technical and economic advantages of the process are emphasized.

(647) Cost Reduction of Powder Metallurgy Techniques. *Product Eng., 19,* No. 2, 134 (1948). Outstanding wartime development in German powder metallurgy appear in report of G. J. Comstock as result of two trips. See also U. S. Dept. of Commerce, Office of Publication Board, PB. 39354r "German Powder Metallurgy."

(648) Powder Metallurgy. *Steel, 122,* No. 13, 89 (1948). Powder metallurgy production methods are detailed with emphasis on factors which affect design, engineering and physical characteristics. Costs of raw materials, tools and dies are included.

(649) Designing Parts Made from Sintered Compacts. H. Chase, *Elec. Mfg., 41,* No. 5, 100-05 (1948). Nominal composition and properties of Cu-base and ferrous alloys for the fabrication of metal compacts are given together with an outline of rules to be followed to obtain lower costs in various designs.

(650) Metal Powder Parts Replace Those Produced by Other Methods. H. R. Clauser, *Materials & Methods, 28,* No. 5, 64-8 (1948). Six case histories are given, showing how metal powder parts can replace conventional metal forms, thereby cutting costs and improving design.

(651) Industrial Application of Powder Metallurgy. A. J. Langhammer, *Metal Progress, 53,* No. 3, 387-389 (1948). An address delivered at Stevens Institute of Technology on occasion of the receipt of fourth annual medal awarded by Institute for outstanding achievement in field of powder metallurgy.

(652) Shaped Machine Parts Produced by Powder Metallurgy. A. J. Langhammer, *Oesterr. Chem. Ztg., 49,* No. 10/11, 190 (1948). International Powder Metallurgy Conference, Graz, Ref. No. 68. Advantages are enumerated as including reduction of costs, production of parts with complicated shapes, large selection of materials, speed of mass production, machine parts with particular properties for electrical and magnetic purposes, parts with self-lubricating surfaces.

(653) Structural Parts of Iron Produced in U.S. F. V. Lenel, *Oesterr. Chem. Ztg., 49,* No. 10/11, 190 (1948). International Powder Metallurgy Conference, Graz, Ref. No. 64. Author refers to industrial aspects of powder metallurgy. Series of 50,000 pieces and more are produced in U. S., mostly by companies which specialize in compressing and sintering, with steady and accurate control of the powders. By the development of powders of higher compressibility it is possible to produce articles with greater wearability.

(654) Aspects of Powder Metallurgy in Spain. F. T. Serrataco and J. A. Morales Belda, *Oesterr. Chem. Ztg., 49,* No. 10/11, 193 (1948). Spain delivers important raw materials for powder metallurgy, *e. g.*, 10% of tungsten of world production.

(655) Powder Metallurgy. Low Cost Equipment for Volume Production. R. Talmage, *Iron Age, 161,* No. 15, 86-91 (1948). A potential method for combating rising costs is in the application of powder metallurgy by large scale production of small parts; an economic analysis is presented, whereby the costs of making a typical part are compared when made in a screw machine and from metal powder.

(656) Status of Production Technique of Iron Powder Metallurgy. H. Timmerbeil and O. H. Hummel, *Arch. Metallkunde, 2,* 30 (1948). General review covering Fe-powder production, molding, coining, sintering and subsequent treatments.

(657) Costs Cut with Powdered Parts. *Machinist, 93,* 1211-12 (1949). Details are given of a dating mechanism in a business machine and four parts used in an automatic filling bobbin winder. Savings claimed to range from 33% to 88% over bar stock.

(658) Close Tolerances at Low Cost. *Metal Powder Press, 1,* No. 1, 2 (1949). A nickel-silver magneto governor weight is made from metal powder; precision casting would be four times higher in cost.

(659) Where Porosity Helps. *Metal Powder Press, 1,* No. 1, 2 (1949). The cost of a machine part previously made by stamping, coining and sizing could be cut in half by using powder metallurgy.

(660) Business Machine Dating Mechanism. *Metal Powder Press, 1,* No. 2, 1 (1949). The two brass gears, shown in an illustration, were specified from brass powder – saving 50% over competitive methods.

(661) Pressed Brass Powder vs. Sand Casting. *Metal Powder Press, 1,* No. 3, 3 (1949). Yale and Towne Manufacturing Co. found that sand casting of brass lock cylinders requires 26 operations, while pressed powder parts require only 12 operations.

(662) 25% Saved by Making Spacers from Horse Head Brass Powder. *Metal Powder Press, 1,* No. 3, 3 (1949). The use of brass powder spacers in an interval timer has helped to yield a neat, compact and economical mechanism.

(663) Domestic Iron Powder Industry Threatened. J. Anthony, *Iron Age, 164,* No. 18, 111-112 (1949). Low cost competition from Sweden seen aided by lower tariff and devaluation of currency. Total production of iron powder in U. S. is 2900 tons/yr.; of imported Swedish powder, 2700 tons/yr. Swedish product undersells domestic by ½ to 6½¢/lb.; duty now only 62½¢/ton (2.75 mils/lb.). Use of domestic powder in U. S. 1500 tons/yr. for parts, 1000 tons/yr. for cores, 100 tons/yr. for sundry applications.

(664) Powder Metallurgy Basis of Substantial Savings. G. W. Beckman, *Purchasing, 26,* No. 6, 142, 144 (1949). Major contribution of powder metallurgy is production of close dimension parts that do not require machining; application requires knowledge of its limitations and advantages; simplicity of process is one of its significant advantages.

(665) Design Engineer Looks on Powder Metallurgy. J. L. Bonanno, *Elec. Mfg., 43,* No. 5, 103, 172, 174, 176 (1949). Some design guideposts and selected case histories that underscore advantages of powder metallurgy techniques.

(666) Dollars-And-Cents Advantages of Powder-Metal Parts. J. L. Bonanno, *Machine Design, 21,* No. 5, 133-6, 180, 182, 184 (1949). Merits of producing products by powder metallurgy techniques, as exemplified by advantages gained by Lionel Corp., Irvington, N. J., in manufacture of toy trains are discussed.

(667) Powder Metallurgy from Design Engineer's Viewpoint. J. L. Bonanno, *Proc. Fifth Ann. Spring Meeting, Metal Powder Assoc.,* Chicago, Apr. 5-6, 1949, 74-92 (1949). Parts of toy locomotive in conventional construction and in powder metallurgy are discussed.

(668) Designing for Production of Parts by Powder Metallurgy. J. L. Bonanno, *Steel, 125,* No. 8, 68-70, 72, 74, 77 (1949). Selection, design and tooling of pressed and sintered structural parts previously made by conventional methods discussed; examples presented from experience of Lionel Corp., Irvington, N. J., in manufacture of model train parts at sizable savings in labor and material; production of laminated structures by powder metallurgy; developments in use of aluminum powders.

(669) Selling Parts Made from Metal Powder. M. Boorky, *Proc. Fifth Ann. Spring Meeting, Metal Powder Assoc.,* Chicago, Apr. 5-6, 1949, 58-63 (1949). Selling conditions are discussed.

(670) Pressed Metal Powder Applications in Automotive Industry. D. C. Bradley, *Iron Age, 163,* No. 12, 86-89 (1949). Oilless bearings represent bulk of metal powder part production; General Motors Corp., Chrysler Corp., and Ford Motor Co. have employed powder metallurgy for making a multitude of functional components and filters; Ford car utilizes 30 powder parts, in addition to bearings and bushings; illustrations of various parts given.

(671) Materials Shortages and Rising Labor Costs Force Changes in Manufacturing Techniques. H. Chase, *Materials & Methods, 29,* No. 1, 60-63 (1949). Casting, sintering, and mechanical forming supplant expensive machining in drive on expense and waste.

(672) Structural Parts From Metal Powders. H. R. Clauser, *Materials & Methods, 30,* No. 3, 85-92 (1949). Materials and Methods Manual No. 52. Description of various metal powders used for structural parts; selection and design of structural parts discussed including quantity and cost factors; heat treating, machining, finishing and welding also considered; illustrations of structural parts given.

(673) Scope and Limitations of Powder Metallurgy Process. E. R. Engstrand, K. M. Gleszer and J. W. Polonetz, *Product Eng., 20,* No. 7, 123-7 (1949). Design limitations discussed include size and shape of parts, part proportions, tolerances, wall thickness, chamfers, relief, ribs, bosses, threads, holes, counterbores, slots, inserts, finned sections, lettering and surface finish; machinability, hardening and finishing; table gives physical characteristics of powder metal test bars.

(674) How Ford Produces Parts from Metal Powders. E. E. Ensign, *Iron Age, 163,* No. 12, 76-80 (1949). Processing method employed for producing more than million bushings per month discussed; description of automatic restriking operation; automatic machining of external grooves in certain types of bushings discussed.

(675) Design in Powder Metallurgy. H. W. Greenwood, *Metallurgia, 40,* No. 239, 255-256 (1949). General observations regarding fundamental rules governing design of parts; three important limitations and how they affect products are listed.

(676) Tolerances of Finished Metal Powder Parts. W. R. Toeplitz, *Proc. Fifth Ann. Spring Meeting, Metal Powder Assoc.,* Chicago, Apr. 5-6, 1949, 36-50. Designs of parts are given and tolerances discussed. Effect of variables on production tolerances; variables affecting sizing tolerances.

4. NOMENCLATURE

(677) Metal Ceramics *vs.* Powder Metallurgy. E. E. Thum, *Metal Progress, 38,* No. 2, 167 (1940). Notes on terminology.

(678) Metal Powders. E. F. Cone, *Metals & Alloys, 14,* No. 6, 841 (1941). Remarks referring to nomenclature.

(679) Terms Used in Powder Metallurgy. *Metal Progress, 41,* No. 1, 44-46 (1942). Dictionary prepared by C. Hardy, R. P. Koehring, C. W. Balke and L. L. Wyman.

(680) Powder Metallurgy Nomenclature. *Metal Treatment, 8,* No. 29, 33, (1942). Sub-committee of Metals Handbook Committee of Am. Soc. Metals defines words in current use in powder metallurgy.

(681) The Definition of "Metal-Ceramic." F. Skaupy, *Metallwirtschaft, 21,* 64, 597 (1942). The author gives an explanation for the use of the word "metal-ceramic."

(682) Glossary of Powder Metallurgy. J. Wulff, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, pp. 1-3. Terms prevailing in the field are defined.

(683) Bronze Powder Redefined. *Iron Age, 153,* No. 7, 168 (1944). Flake type bronze powder is removed from the definition of copper base alloy powders, for which it has been necessary to secure the authorization to receive deliveries from WPB.

(684) Terminology in Powder Metallurgy. H. J. Bartels, W. Hotop and R. Kieffer, *Arch. Metallkunde, 1,* No. 7/8, 311-15 (1947). Authors conducted an enquiry which produced quite widespread agreement on German powder metallurgy terms; these are annotated and listed.

(685) Powder Metallurgy Terms. *Steel, 122,* No. 18, 138-39 (1948). New glossary of terms used in powder metallurgy has been prepared by committee of Am. Soc. for Testing Materials. Definitions of 130 terms.

(686) Tentative Definitions of Terms Used in Powder Metallurgy. Metal Powder Association. M. P. A. Standard 9-50T, 1950, 4 pp. An alphabetical listing of common terms used in powder metallurgy and their definitions.

II. Production and Composition of Powders

1. GENERAL METHODS AND EQUIPMENT FOR POWDER MANUFACTURE

(687) The Manufacture and Use of Metal Powders. J. C. Chaston, *Metal Treatment, 1,* No. 1, 3-10, 12 (1935). A review: machining process, Bessemer process, stamp mills, eddy mills, grinding, granulation, reduction, precipitation, electrodeposition, carbonyl process.

(688) Some Non-Ferrous Metal Powders. J. C. Chaston, *Aluminium and Non-Ferrous Rev., 1,* 229-31 (1936). Manufacture, characteristics and uses of Mg, Al, Cu, Pb, with special reference to correct particle shape.

(689) Methods of Powder Production. J. C. Chaston, *Elec. Commun., 14,* 133-46 (1936). The various methods are presented and summarized in tabular form.

(690) Problems of Modern Metallurgy. L. Guillet, *Génie civil, 109,* 1-7 (1936). Preparation of pure metals by electrolysis, deoxidation, and other methods. Production of Al, Zn, Ni (the latter from their carbonyls) is described.

(691) Powder Metallurgy. J. C. Chaston, *Metallurgia, 15,* No. 87, 95-96 (1937). Production of metal powders and their uses. A review.

(692) Production of different metals in the Laboratory. H. Funk, *Darstellung der Metalle im Laboratorium.* Ferdinand Enke, Stuttgart, 1938, 183 pp. Reduction in streaming hydrogen, alumino-thermic processes, electrolysis precipitation are described.

(693) Production of Metal Powders. D. O. Noel, J. D. Shaw and E.B.Gebert, *Metal Ind. (London), 53,* 315-18; 349-53 (1938). A review of the various methods is given. *Cf. Trans. Am. Inst. Mining Met. Engrs., 128,* 37-56 (1938).

(694) Production and Some Testing Methods of Metal Powders. D. O. Noel, J. D. Shaw and E. B. Gebert, *Trans. Am. Inst. Mining Met. Engrs., 128,* 37-56 (1938). Machining, milling, shotting, graining, atomization, condensation, carbonyl process, reduction, precipitation, electrolysis are described.

(695) Making and Measuring Metallic Powders. *Metal Progress, 37,* No. 4, 430 (1940). Brief note on production and physical testing of metal powders at Metals Disintegrating Co., New Jersey.

(696) Powder Metallurgy. F. Neurath, *Chem. Age (London), 44,* 255-6 (1941). Field for new developments – Various methods of powder production are described: carbonyl powders, mechanical processes for metal powders, Schoop process.

(697) Powder Production and Classification. D. O. Noel, *Powder Metallurgy*, Am. Soc. Metals, Cleveland, 1942, Chap. 8, pp. 109-123 (1942). Machining, milling, shotting, graining, atomization, condensation, carbonyl process, reduction, electrolysis, precipitation, hydride process are described.

(698) The Technical Processes for the Production of Metal Powders. J. Reitstötter, *Kolloid-Z., 103*, No. 2, 182-184 (1943). Review of the most important patents (mainly German) covering various processes by which metal powders can be produced. Tabulation of chemical and electrolytic processes for the production of metal powders.

(699) Materials and Methods Manual 2. E. E. Schumacher and A. G. Souden, *Metals & Alloys, 20*, No. 5, 1327-1342 (1944). Appendix table is published by editors of *Metals & Alloys* on metal powder suppliers.

(700) Metal Powders. *Automobile Engr., 35*, 353 (1945). Production methods and their advantages are briefly reviewed.

(701) Metallic Powders. *Metallurgie & Construction Mécanique, 78*, No. 11, 15-21 (1946). Metal powder preparation by mechanical and physico-chemical methods are reviewed, and the physical and chemical properties of metal powders are discussed.

(702) Manufacturing Bronze, Aluminum or Other Flake Metal Powders. H. F. Mandle, U. S. Dept. Comm. PB. 17559; *Bibl. Scient. & Ind. Rept., 1*, No. 22, 1341 (1946). Most modern equipment for the manufacture of Al and related flake powders was found in several plants in Germany.

(703) Notes on German Production Methods at Düsseldorfer Eisenhüttengesellschaft and Deutsche Eisenwerke. J. C. Richards, *B.I.O.S.* Final Rept. No. 860. Results of investigations on the Hametag and DPG processes.

(704) Production of Ferrous and Non-Ferrous Metal Powders. G. L. Miller, *Symposium on Powder Metallurgy*, The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 8-14; *Met. Powd. Rept.*, I, No. 11, 162 (1947). The processes used for the production of metal powders are classified in eleven groups. The applications of each method and the characteristics of the powder produced by it are briefly discussed, and the methods of production and properties of powders of the common industrial metals are tabulated.

(705) Powder Metallurgy. G. Oldham, *Mining J. (London), 229*, 702-707 (1947). Chemical, physical, mechanical methods of manufacture of metal powders are reviewed.

(706) Manufacturing Bronze, Aluminum, and Other Metal Powders. H. R. Williams, F.I.A.T. Final Rept. No. 569, 1947, 10 pp. A description is given of processes employed for metal powder production at various German plants.

(707) Metal Powders. G. L. Miller, *Can. Metals Met. Inds., 11*, No. 10, 18, 44-46 (1948). Production of metal powders are grouped into milling, machining, atomization, granulation, graining, reduction of metallic oxides, reduction of metal salts, electrolysis, carbonyl process; each method is discussed briefly.

(708) A Survey of Powder Metallurgy Processes — I. L. A. Durán, *Rev. cienc. Applicada, 3*, No. 2, 81-94 (1949). Description of various processes of powder manufacture is given; a table shows the method of production of 28 metal powders, with purity, size and aspects of the product.

(709) The Metal Powders. W. Wirth, *Einführung in die Pulvermetallurgie*. Technische Hochschule, Graz, pp. 34-54. The production of metal powders is described: mechanical processes, physical and chemical methods. A survey of different methods of production, and uses of specific metal powders, analysis of sieving and testing methods is included in the discussion.

A. Mechanical Processes (machining, crushing, milling, graining, shotting, atomizing, liquid disintegration)

(710) Theophilus (Pseudonym), *Schedula Divarsarum Artium*, Probably 11th Century (Latin Text, English Translation by R. Hendrie, London, 1847; German Translation by W. Theobald, Berlin, 1933). A full description is given of the mill used in the 11th century for making powders from gold, silver, copper, brass or tin.

(711) L. Ercker, *Beschreibung Allerfürnemisten Mineralischen Ertzt und Berckwercksarten*, Prague, 1574-1580. This book on assaying contains woodcuts illustrating the granulation of gold and silver by pouring the molten metal onto a broom moving under water.

(712) J. A. Cramer, *Elementa Artis Docimasticae*, Leyden, 1739 (English translation, London, 1741). Finely powdered lead alloy for assayers' use was produced by mechanical disintegration in the temperature range between liquidus and solidus.

(713) L. E. Andés, *Blattmetalle, Bronzen und Metallpapiere*. Hartlebens, Vienna-Leipzig, 1902. Methods to produce flake metal powders by mechanical comminution are reviewed on pp. 100-103.

(714) H. Fischer, *Technologie des Schneidens, Mischens und Zerkleinerns*. Spamer, Leipzig, 1920. A discussion of stamping machinery is given on pp. 246-324.

(715) **Researches on the Theory of Fine Grinding.** G. Martin, C. E. Blythe, and H. Tongue, *Trans. Ceram. Soc. (England), 23*, 61-120 (1923/24). A law governing the connection between the number of particles and their diameters in the grinding of crushed sand is established.

(716) **Studies of the Theory of Fine Grinding.** G. Martin, C. E. Blythe, and H. Tongue, *Trans. Ceram. Soc., (England), 25*, 63-81, 226-257,(1925/26). Connection between the surface area produced and the work done in tube-mill grinding of quartz sand is investigated.

(717) C. Mittag, *Der Spezifische Mahlwiderstand*. VDI-Verlag, Berlin, 1925. The milling and grinding capacity of solids is treated.

(718) **The Granulation of Metals.** A. E. Smith, *Metal Ind. (London), 35*, 387-90 (1929). Experiments cover Cu, Zn, Sn, Ni, Au, Ag as well as brasses and nickel alloys. Details of procedure, *e. g.*, temperature of molten metal, orifice dimensions, pressure, *etc.*, and their effect on the particle size of the resulting powder are discussed.

(719) **Manufacture of Bronze Powder.** *Cuivre et Laiton, 3*, 107 (1930). An alloy is rolled out into extremely thin strips and then pounded in a special mill to cause it to fracture into fine pieces, which are polished by tumbling in another mill.

(720) **Colloidal Mills.** A. Chwala, *Kolloid-Z., 53*, 266-267 (1931). Discussion of German patent 387,995 of Plauson's Forschungsinstitut; German patents 400,307 and 405,381 of Hartstoff Metall A. G., concerning the disintegration of metals in eddy mills.

(721) **Eddy Mills.** E. Podszus, *Kolloid-Z., 54*, 124 (1931). Remarks to the patent discussions "Colloidal Mills" by A. Chwala. The "Hametag" process of pulverizing iron wire into fine powder is described.

(722) **Mechanical Pulverization Down to the Colloidal State.** E. Podszus, *Kolloid-Z., 64*, 129-143 (1933). Process developed by author which permits grinding of any metal from hard steel to soft lead at room temperature down to any given grain size.

(723) **Structure of Granulated Lead.** G. Tammann and K. L. Dreyer, *Z. Metallkunde, 35*, 64 (1933). In granulating lead, arsenic is added as a minor alloying constituent to prevent the formation of elongated drops and particles.

(724) Apparatus for the Grinding of Copper in High Vacuum and the Absorption of Gases by the Resulting Powder. F. Durau and H. Franssen, *Z. Physik, 89,* 757-73 (1934). Elaborate apparatus is described.

(725) Ball Milling for Metal Reclamation. G. F. Metz, *Metals & Alloys, 18,* No. 1, 63-65 (1934). Reclamation of Al, Zn and brass scrap by ball milling. Conical ball mills are used for salvage operation.

(726) Laws of Milling. P. Rosin and E. Rammler, *Ber. deut. Keram. Ges., 15,* 399-416 (1934). A theoretical and practical discourse of grinding and milling processes is given.

(727) New Process for the Manufacture of Aluminium-Bronze and Like Powders. A. Dumas, *Rev. Aluminium, 12,* 2739-2744 (1935). The Hametag process is described.

(728) M. U. Schoop and C. N. Daeschle, *Handbuch der Metallspritztechnik.* Rascher, Zürich-Leipzig-Vienna, 1935. The subjects of spraying and atomizing of liquid metals and the production of metallic powders by this procedure are treated.

(729) Apparatus for Preparation of Absorbing Metal Powders. F. Durau, *Physik. Z., 37,* No. 19, 684-88 (1936). The apparatus for the production of Ni, Cu and Ag powders in N_2 atmosphere, and the removal of the adsorbed protective gas from the surface of the particles by evacuation is described.

(730) F. Hönig, *Grundgesetze der Zerkleinerung.* VDI-Verlag, Berlin, 1936. A theoretical and practical discourse on the disintegration of solids.

(731) A Contribution to the Knowledge of the Disintegration Process. A. H. M. Andreasen, B. Wesenberg and E. G. Jespersen, *Kolloid-Z., 78,* 148-56 (1937). The characteristics for the conditions of disintegration of intimate millings are discussed.

(732) The Efficiency of the Processes of Mechanical Disintegration. A. Smekal, *Chem. Fabrik, 10,* 503-4 (1937). The differences between the mechanical disintegration and the crushing of single grains are discussed.

(733) Theoretical Basis for the Comminution of Hard Substances. A. Smekal, *Z. Ver. deut. Ing. Beiheft Verfahrenstechnik,* No. 1, 1-4 (1937). The author discusses his theory of breaking down of compact brittle bodies, which provides for a numerical designation of the properties significant for the grindability of simple matters.

(734) Development in the Manufacture of Metal Powders. J. C. Chaston, *Metal Treatment, 4,* 49-52 (1938). Hall and Hametag processes are described.

(735) Determination of the Milling Capacity of Solid Substances. W. Gründer, *Z. Ver. deut. Ing., Beiheft Verfahrenstechnik,* No. 1, 17-23 (1938). A general review of the mechanical disintegration of solid matter is presented.

(736) Ball, Rod, and Tube Mills. W. H. Withington, *Ind. Eng. Chem., Ind. Ed., 30,* 897-904 (1938). The different kinds of mills are described.

(737) Movements in Vibratory Mills. D. Bachmann, *Z. Ver. deut. Ing., Beiheft Verfahrenstechnik,* No. 2, 43-55 (1940). A theoretical and practical analysis of the milling processes.

(738) Deleterious Coatings of the Media in Dry Ball Milling. F. C. Bond and F. T. Agthe, *Mining Technol.,* T. P. 1160, B 96 (1940). In dry-grinding of fine sizes, the grinding media often become coated with the material being ground. This coating cushions the impacts and inhibits further grinding. Comparative effects on different materials and sizes are given. Small amounts of certain reagents reduce coatings in some instances, probably by adsorption.

(739) Development of the Vibratory Mill. D. Bachmann, *Chem. Tech. (Berlin), Ver. Chem. Appa., 15,* 107 (1942). Brief review.

(740) Crushing Machines. C. Mittag, *Tech. Mitt. Krupp, 10,* 46-54 (1942). Ball mills, hammer mills, and tube mills are described.

(741) Superfine Grinding of Metal Powders. M. Olbrich, *Light Metals, 7,* No. 75, 157-60 (1942). A study was made of grinding of an aluminum foil into fine

particles in a vibrating ball mill with porcelain balls, steel balls, with and without lubricants. Progress in grinding is shown by means of graphs.

(742) Wear and Size Distribution of Grinding Balls. F. C. Bond, *Trans. Am. Inst. Mining Met. Engrs., 153,* 373-385 (1943). A theoretical analysis is presented including a formula for ball wear, equilibrium ball charge, initial ball charge, and ball-size differential.

(743) Superfine Grinding of Metal Powders. *Light Metals, 7,* No. 4, 157-160 (1944). Resume of recent research by Olbrich on comminuting of aluminum in the vibrating ball mill.

(744) Metals Disintegrator. *Metals & Alloys, 20,* No. 2, 496 (1944). A new apparatus disintegrates almost any metal into a small multifractured chip that can be converted to a fine powder with one hammermill operation. Manufactured by the Franklin-McAllister Corp.

(745) Fracture and Comminution of Brittle Solids. E. F. Poncelet, *Trans. Am. Inst. Mining Met. Engrs., 158,* 333-341 (1944). Comminution of brittle solids occurs in deformation of the solid to be comminuted by the application of outside forces resulting in tensile stress; development of one or more cracks as a direct result of these stresses; formation of compression and transverse pulses caused by these breaks to travel through the solid; formation of residual particles of increasingly smaller sizes.

(746) Dry Size Reduction in Fine Size Range. C. E. Berry, *Ind. Eng. Chem., Ind. Ed., 38,* No. 7, 672-78 (1946). The micro-atomizer, the micronizer, the reductionizer, the eagle mill, and the Raymond vertical mill are described.

(747) Special Alloy Steel Manufacture and Centrifugal Casting of Alloy Tubes and Gun Barrels. T. P. Colclough, C.I.O.S. Rept. No. XXXI-46 (1946). Contains one section on the D.P.G. rotating disk process for making iron powder.

(748) Minutes of a Conference on Production of Iron Powder according to the D.P.G. Method in 1946. Deutsche Eisenwerke, Mülheim, F.D. Rept. No. 1541/46 (1946). Details of the water nozzle and of the chemical analyses of D.P.G. and S.C. powders. The blades should be of chromium steel (German qualities quoted).

(749) Reports on Preparation of Metal Powder from Liquid Metal. Deutsche Pulvermetallurgische Gesellschaft, Frankfurt a/Main, F.D. Rept. No. 1725/46 (1946). Contains a confidential report on rotating disk atomizing (December, 1939); results of work on disk-atomized Fe-Cu powder (3.3% and 5.0% Cu) in which tensile strengths of approximately 66,000 psi were obtained (September, 1941).

(750) Deutsche Gold und Silber Scheideanstalt, Frankfurt. W. A. M. Edwards and J. H. Clayton, B.I.O.S. Final Rept. No. 423 (1946). The Degussa-operated D.P.G. process at Frankfurt and an aluminum atomizing process at the Norddeutsche Affinerie, Hamburg, are described.

(751) Vibrating Ball Mill for Pulverizing Fine Materials. P. M. Tyler, U.S. Dept. Comm. PB. 40283/1946, 20 pp.; *Bibl. Scient. & Ind.Rept., 3,* No. 4, 259 (1946). *Cf:* F.I.A.T. Rept. No. 754 (1947).

(752) Production of Iron and Other Metal Powders. *Chem. Age (London), 56,* No. 1453, 641 (1947). German practices of powder production are discussed in this abstract from B.I.O.S. Final Rept. No. 706. Atomization of powders by various processes, *e.g.*, the D.P.G. rotating disk process, is described in particular. The powder was found suitable for the fabricating into sintered parts..

(753) Production of Iron Powder. Demag A. G., Berlin, F.D. Rept. No. 456/47 (1947). Five sets of drawings for a D.P.G. iron disk-atomizing plant, dated 1942-44. (condition of drawings very poor, only partly legible).

(754) Rotating Disk Apparatus for the Production of Iron Powder. Demag A. G., Mülheim, F.D. Rept. No. 879/47 (1947). A probably complete set of drawings, dated 1941-44, showing the general arrangement and details.

(755) Rotating Disk Machine for the Production of Powder for Sintered Components. Demag A. G., Duisburg, F.D. Rept. No. 997/47 (1947). Contains a set of 39 drawings, dated 1942-44, in generally good condition.

(756) R. Herrmann, *Probleme der Feinzerkleinerung*, Dissertation, Univ. Berlin, 1947. A thorough investigation is made of the effects of various conditions, *e. g.*, dimensions, material of mill construction, milling product, time of milling, wet *vs.* dry milling, on the milling in vibratory and other mills.

(757) German Aluminum and Bronze Flake Powder Industry. T. Hewitt, G. L. Luzky, H. Meyersberg and P. L. M. Rink, B.I.O.S. Final Rept. No. 729, 195 pp; *Met. Powd. Rept., 1*, No. 7, 99 (1947). Vibrating ball mill made by Siebtechnik G.m.b.H., having stainless steel ball mill containers placed on a carrier supported on springs. Report comprises evaluation of ten most important German flake powder companies.

(758) The Preparation of Filings for Debye-Scherrer Diffraction Photographs. W. Hume-Rothery, *J. Sci. Instruments, 24*, 75 (1947). Describes an appliance for preparing filings for Debye-Scherrer diffraction photography either in vacuo or in atmosphere of inert gas.

(759) Metal Powder Production with "Hametag-Process." H. Kramer, *Metall, 1*, No. 5/6, 73-76 (1947). Atomization in a mill with rotating disks can be varied in several ways: small distances between the blades and walls result in spherical particles and small "shake volume." The turbo-blower effect in mills. Combination of disintegration by rotating disk action and by particle collision can be obtained.

(760) Flake Metal Powders — Their Application, Manufacture and Testing. H. Meyersberg, *Symposium on Powder Metallurgy*. The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 37-46; *Met. Powd. Rept., 1*, No. 11, 162-163 (1947). Description of the two prevailing manufacturing processes: stamping and modified ball milling using inert atmosphere.

(761) Principles of Pulverizing of Metals. E. Podszus, *Arch. Metallkunde, 1*, No. 7/8, 318-22 (1947). Fundamentals and laws of pulverization; physical and structural principles of mills; surface tension and surfaces; sources of loss.

(762) Study of Process Variables in the Production of Aluminum Powder by Atomization. J. S. Thompson, *J. Inst. Metals, 74*, pt. 3, 101-32 (1947). Of variables investigated, those concerned with nozzle design are of relative minor importance. Rate of atomizing found related to variables: metal head, air pressure, metal temperature, area of metal orifice. General explanation of mechanism outlined.

(763) Vibrating Ball Mill for Pulverizing Fine Materials. P. M. Tyler, F.I.A.T. Rept. No. 754, 14 pp.; *Met. Powd. Rept., 1*, No. 10, 146 (1947). Description of vibration mill with operating results for Al powder.

(764) Crushing and Milling. L. T. Work, *Ind. Eng. Chem., Ind. Ed., 39*, 11, 31 (1947). The grindability and measurement of particles are described, and pertinent references are given.

(765) Details of German Powder Metallurgy Powder Production by Liquid Disintegration. R. L. Bickerdike and R. Chadwick, B.I.O.S. Final Rept. No. 1569 (1948). Molten mild steel or low-silicon cast iron is poured through a nozzle into the apex of a water cone, the shock-chilled particles being further distorted by action of fast revolving stainless steel knives.

(766) Steel and Non-Ferrous Powders Produced by D.P.G. Process. F. Rapatz and F. Schmidt, *Met. Powd. Rept., 3*, No. 1, 11 (1948); *Oesterr. Chem. Ztg., 49*, No. 10/11, 180 (1948). International Powder Metallurgy Conference, Graz, Ref. No. 37.D.P.G. disk iron powder contains 2-3% O, regardless of C content. With rapid annealing some carbon is retained in the center of particles, giving 0.2% O, though this may also be due to subsequent absorption. Examples of powders produced are Ni-, Cr-, and Si- steels, and Cu, brass, Al, Zn and Sb.

(767) Method for Wear and Tear Reduction in Screenless Ball Mills. H. J. Salosu, *Z. Erzbergbau u. Metallhüttenwesen, 1*, 50-52 (1948). This is accomplished by partial replacement of the steel lining with beechwood lasts, whereby about 24% of weight can be saved, or by armor of hard wood and steel billets which has a greater life. The specific net wear on armor and mill body in g. per ton amounts to about 111.6 g. per ton in the latter case.

(768) Vibratory Milling. S. Kieskalt, *Z. Ver. deut. Ing., 91,* 313-15 (1949). Review of latest practices.

(769) Fundamental and Recent Findings in Fine Milling. G. Quittkat, *Z. Erzbergbau u. Metallhüttenwesen, 2,* 6-14 (1949). A review of practical experiences and some theoretical aspects.

B. Physical Processes (evaporating, condensing, distillation, sublimation, thermal decomposition and dissociation, carbonyl)

(770) On the Decomposition of Nickel Carbonyl in Solution. V. Lenher and H. A. Loos, *J. Am. Chem. Soc., 22,* 114-16 (1900); *J. Chem. Soc., 78,* 349-50 (1900). A solution of nickel carbonyl will, after standing, suffer decomposition with formation of a gelatinous precipitate. The metal powder is the end product.

(771) The Preparation of High Temperature Refractory Metals from Their Chlorides. J. N. Pring and W. Fielding, *J. Chem. Soc., 95,* 1497-1506 (1909). A report is given on the separation of tungsten by distillation of the hexachloride and subsequent thermal decomposition.

(772) Condensation of Metallic Vapors. V. Kohlschütter and C. Ehlers, *Z. Elektrochem., 18,* No. 10, 373 (1912). Condensation of As, Se, Cd, Zn results in powder products of various particle size and other characteristics. Powders may be compared by microscopic examination.

(773) The Growing of Metal Crystals by Separation from a Gaseous Phase. F. Koref, *Z. Elektrochem., 28,* No. 23, 511-17 (1922). The phenomenon of the growth of a single crystal is described.

(774) Iron Carbonyls: Their Physical and Chemical Properties. G. W. Jones and A. C. Fieldner, *Am. Gas Assoc. Monthly, 6,* No. 7, 439-446 (1924). Action of carbon monoxide on iron is included in a general discussion of metal carbonyls. Ferropentacarbonyl is referred to specifically.

(775) The Growing of Metal Crystals by Separation from a Gaseous Phase. H. Fischvoigt and F. Koref, *Z. tech. Physik, 6,* No. 7a, 296-98 (1925). Reference is made to the growing of tungsten crystals.

(776) Production of Pure Titanium, Zirconium, Hafnium and Thorium. A. E. Van Arkel and J.H. de Boer, , *Z. anorg. allgem. Chem., 148,* 345-50 (1925). Production methods of pure metals and alloys employing the vapor decomposition methods and the metal halides as starting material are described.

(777) Preparation of Pure Metals of the Titanium Group by Thermal Decomposition of the Iodides. J.H. de Boer and J. D. Fast, *Z. anorg. allgem. Chem., 153,* 1-8 (1926). Zr, produced from volatile iodides by thermal dissociation, is condensed onto a metal wire according to the method of A. E. Van Arkel.

(778) Separation of Metals from the Gas Phase. A. E. Van Arkel, *Chem. Weekblad., 24,* 90-6 (1927). The method involves heating a metal wire in the vapor of a dissociating compound of the metal to be prepared.

(779) Preparation of Pure Metals of the Titanium Group by Thermal Decomposition of the Iodides. J.H. de Boer and J. D. Fast, *Z. anorg. allgem. Chem., 187,* 177-192 (1930). Methods of reduction; influence of foreign matters; influence of gases; zirconium.free of hafnium.

(780) J. A. M. Van Liempt, *Die Afscheiding van Wolfram uit Gasformige Verbindingen en hare Toepassing.* Purmerund, 1931. The vapor deposition process is described as it applies to various rare metals.

(781) Derivatives of Cobalt- and Nickel-Carbonyl. W. Hieber, F. Hühlbauer, and E. A. Ehmann, *Ber., 65,* 1090-1100 (1932). The production and properties of the derivatives, *e.g.*, the metal powders are described.

(782) Diffusion of Titanium and Dissociation of Titanium Compounds. I. S. Gaev, *Metallurg , 9,* No. 10, 19-33 (1934). An early carefully conducted and thorough diffu

study of diffusion of titanium in iron is reported. Data on iron-titanium metal powders and on dissociation of titanium compounds are given.

(783) Production of High-Melting Metals by Thermal Dissociation of Their Compounds. A. E. Van Arkel, *Metallwirtschaft, 13,* 405-8, 511-4 (1934). Discussion of method of producing metallic Ti and V by decomposition of their iodides.

(784) The "Solutier" Process of Vaporizing Metals in Arc Furnaces. H. Masukowitz, *Elektrowärme, 8,* No. 9, 233-237 (1938). Manufacture of fine lead and zinc powders.

(785) The Metal Carbonyls. VII – Industrial Significance. W. E. Trout, Jr., *J. Chem. Ed., 15,* No. 3, 113-21 (1938). Fe and Co carbonyls, and their thermal decomposition to carbonyl Fe and Co powders are discussed.

(786) Production of Pure Metals of the Titanium Group by Thermal Decomposition of their Iodides. J. D. Fast, *Z. anorg. allgem. Chem., 241,* 42-56 (1939). Production of titanium raw metal and of ductile titanium by working at 500-550° C. (930-1020° F.) are described. Influence of temperature on grain growth is shown.

(787) A. E. Van Arkel, *Reine Metalle.* Springer, Berlin, 1939. On pp. 181-220 the method of producing rare, refractory metals by dissociation of their halides and condensation on a tungsten or other refractory metal filament at high temperatures is described.

(788) Sinter Metallurgy and Decomposition Metallurgy. J. D. Fast, *Oesterr. Chem. Ztg., 43,* No. 3, 27-33, 48-54 (1940). Decomposition of a volatile compound on a hot surface; 40 references. Production of Ti and Zr by thermal dissociation of their iodides; Ni and Fe produced by decomposition of their carbonyls.

(789) Investigation of the Production of Monodisperse Substances. A. H. M. Andreasen, K. Skeel-Christensen, and B. Kjaer, *Kolloid-Z., 104,* No. 2/3, 181-88 (1943). Various compounds with a particle size between 0.3 and 3 microns are produced by condensation.

(790) The History of Metal Carbonyls. A. Mittasch, *Kolloid-Z., 104,* No. 2/3, 139-41 (1943). A brief historical review of the production of Fe, Ni, and other metal powders obtained by the thermal decomposition of their respective carbonyls.

(791) Ultrafine Iron Powder. E. J. Kohlmeyer and H. Spandau, *Arch. Eisenhüttenwesen, 18,* 1-6 (1944/45). Obtained by vaporization of iron by means of an air or oxygen blast on carbon-rich molten metal, or by adaptation to iron of the method of vaporizing in the electric arc ("Solutierverfahren").

(792) Deposition of Metals from the Gaseous Phase, Especially by Decomposition of Carbonyls and Application of Resulting Products. H. Borchers, U.S. Dept. Comm. PB. 14956; *Bibl. Scient. & Ind. Rept., 1,* No. 22, 1339 (1946). The report to representatives of U.S. Army by the director of the metallurgical department of Munich School of Technology includes the production of metallic coatings and the growing of metal filaments.

(793) German Iron and Nickel Powders. T. P. Colclough, *Iron Age, 157,* No. 8, 48-49 (1946). A review is given of the C. I. O. S. Rept. No. XXIV-12, made on the industrial scale production of carbonyl iron and nickel powder in Germany during the war. The report was based on visits of the Oppau works of the I. G. Farbenindustrie.

(794) Iron and Nickel Powder Production Log Books of 1944. I. G. Farbenindustrie A. G., F. D. Rept. No. 210/46 (1946). Half-hourly entries for the respective carbonyl powder plants.

(795) Method for Evaporation of Alloys. L. Harris and B. M. Siegel, *J. Applied Phys., 19,* 739-741 (1948). A powdered alloy on a belt is fed into electric heated boat, all contained in a bell jar evacuated below 10^{-4} mm. Hg. Tests on brass and on a Au-Cd alloy show by chemical and electron-diffraction analyses that the components of the alloy are held to within close limits in spite of differences in vapor pressure of the components.

(796) Heavy Metal Recovery from Scrap Material. F. Kaiser, *Z. Erzbergbau u. Metallhüttenwesen, 1,* 43-44 (1948). Vaporization of molten brasses in a rotary furnace; treatment of scrap metal in a high frequency furnace in vacuo and electrolysis are discussed.

C. Chemical Processes (precipitation, replacement, dissolution, reduction, carburization, decarburization, oxidation)

(797) Tungsten Metal. L. Weiss and A. Martin, *Z. anorg. Chem., 65,* 279-340 (1910). Wolframite was reduced by the aluminothermic process, producing iron-manganese-tungsten alloys.

(798) The Höganas Process. S. Sieurin, *Jernkontorets Ann., 95,* 448 (1911); *Stahl u. Eisen, 31,* 1391-94, 1518 (1911). The Höganas process of reducing iron oxide with carbon is described.

(799) Reduction of Highly Reactive Metals. E. Podzus, *Z. anorg. allgem. Chem., 99,* 123 (1917). Titanium chloride or potassium zirconium fluoride is mixed with metallic sodium in a steel bomb which contains steel balls. The apparatus revolves for 24 hrs. to bring the reacting substances into intimate contact. The reaction is started by heating. Pure metals, *e.g.*, Ti or Zr, result in powder form.

(800) Reduction of Tungsten Oxide. C. W. Davis, *J. Ind. Eng. Chem., 11,* No. 3, 201-04 (1919). Preliminary experiments to produce W powder. Reduction with charcoal in an iron tube. Reduction with lamp black in a fire-clay crucible. Reduction with gas.

(801) Reducing of Tungsten Ores. T. Sington, *Eng. Mining J., 109,* No. 15, 879-880 (1920). The principal difficulty is to separate pure tungstic oxide from the crude ore; reducing agents, such as C or H, are used to produce the tungsten metal in powdered or sponge form.

(802) Making Steel Direct from Ore. *Iron Trade Rev., 68,* 1375 (1921). The claim of a French inventor that steel can be made by a direct process in five hours recalls many past and present attempts. Basset and Jones processes are compared.

(803) The Basset Process. F. Wüst, *Stahl u. Eisen, 41,* No. 51, 1841-48 (1921). The rotating furnace is described and compared with other constructions used for production of sponge iron, etc.

(804) Reduction of Thorium Oxide by Tungsten. C. J. Smithells, *Trans. Chem. Soc., 121,* 2236-38 (1922). Experiments show that thorium metal can be produced by reaction between tungsten and thoria.

(805) Reduction of Iron Oxides by Fuel Gases. E. D. Eastman, *U. S. Bur. Mines, Rept. of Investig. 2485,* 1923, 14 pp. The factors of reduction form two classes, those which affect the equilibrium between the reacting substances and products, and those which affect the rate of reaction.

(806) The Reduction of Some Rarer Metal Chlorides by Sodium. M. A. Hunter and A. Jones, *Trans. Electrochem. Soc., 44,* 23-30 (1923). The reduction of $CrCl_3$ with Na in a sealed container is described.

(807) Reduction of Thorium, Zirconium, and Titanium Dioxides. O. Ruff and H. Brintzinger, *Z. anorg. allgem. Chem., 129,* 267-68 (1923). Reduction in wrought iron bomb is effected by means of Na or Ca as reagent.

(808) The Hydrogen Reduction of Difficultly Reducible Metal Oxides. H. von Wartenberg, J. Broy and R. Reinicke, *Z. Elektrochem., 29,* 214-17 (1923). ZrO_2 and ThO_2 can be reduced by hydrogen in the presence of W which is capable of dissolving the reduced metal. The tungsten furnace used for the reduction is described.

(809) Direct Production of Iron. E. Fornander, *Chem. & Met. Eng., 30,* No. 22, 864-65, 907-08 (1924). The reduction processes of Chenot, Gurlt, Husgafvel, Wiborgh, Gröndal, Sieurin, Bourcoud, Berglöf, Wiberg, and Basset are described.

(810) Preparation of Tungsten and Alloys. L. Kahlenberg and H. Kahlenberg, *Trans. Am. Electrochem. Soc., 46,* 181-95 (1924). The reduction of tungsten oxide with zinc is described.

(811) Process for Production of Sponge Iron. C. E. Williams, E. P. Barrett and B. M. Larsen, *U. S. Bur. Mines, Rept. of Investig. 2578,* 1924, 5 pp. Process and furnace are described; internally and externally heated furnaces are compared. Sponge iron and steel products.

(812) Gaseous Reduction of Iron Oxides. E. Edwin, *Tek. Tidskr. Bergvetensk., 56,* 41-51 (1926); *Tek. Ukeblad, 73,* 225-35 (1926). The "Norsk-Staal" process is described.

(813) Reduction of Powdered Substances Weighed in Air and Vacuum – II. R. Ruer and J. Kuschmann, *Z. anorg. allgem. Chem., 166,* 257-74 (1927). Production of Cu-oxide by precipitation of Cu-nitrate with caustic potash solution.

(814) A New Method for the Production of Iron Sponge. M. Wiberg, *Trans. Am. Electrochem. Soc., 51,* 279-304 (1927). It is shown that the gaseous reduction can be carried out continuously with very low consumption of fuel and electrical energy.

(815) Reduction of Tungsten by Hydrogen. G. A. Meerson, *J. soc. phys. chim. russe, 60,* No. 8, 1217 (1928); *J. Inst. Metals, 41,* 411 (1928). The growth of the crystals of W does not commence below 1200° C. (2190° F.) if the metal powder is heated in dry H; should latter contain moisture, the growth commences at 1050° C. (1920° F.) and is accompanied by a loss in weight.

(816) Reduction of Chromium Oxide. H. H. Meyer, *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf, 13,* 199-204 (1931). Chromium oxide was reduced by hydrogen in the presence of carbonyl iron, and the degree of reduction determined for different amounts of the oxide, as well as for different temperatures and times.

(817) Tungsten Oxide – W_4O_{11}. E. Tarjan, *Naturwissenschaften, 19,* 166-67 (1931). A discussion is given of the reduction of oxides of tungsten.

(818) The "Norsk-Staal" Method for the Production of Sponge Iron. I. Bull-Simonsen, *Stahl u. Eisen, 52,* 457-61 (1932). The "Norsk-Staal" gaseous iron oxide reduction process is discussed and the gas recirculation plant described.

(819) Sponge Iron Process. B. Kalling, *Tek. Tidskr. Bergvetensk., 62,* 48-54 (1932). A process of reducing iron oxide with carbon to sponge iron is described.

(820) Sponge Iron. M. Tigerschiöld, *Blad Bergshandteringens Vänner, 20,* 240-267, *21,* 219-229 (1932); *Stahl u. Eisen, 52,* 1244-46 (1932). Describes the reduction methods used in Sweden (Kalling process) for the production of sponge iron from iron oxide.

(821) F. Ullmann, *Enzyklopädie der technischen Chemie,* 3rd Ed., Urban & Schwarzenberg, Berlin-Vienna, 1932. In Volume 10, pp. 517-37, a description is given of large scale reduction of tungstic oxide with carbon. The reaction is carried out in graphite or fireclay crucibles, and the conditions for reduction are given.

(822) Norsk-Staal Process. P. Goerens and P. Gebhard, *Rév. tech. Luxembourgoise, 25,* 30-33 (1933). A gaseous reduction plant of this type produced till 1932 in Bochum, Germany, about 20,000 tons annually of sponge iron.

(823) Sponge Iron Process. B. Kalling, *Tek. Tidskr. Bergvetensk., 63, Suppl.,* 65-71 (1933). A process of reducing iron oxide with carbon to sponge iron is described.

(824) Mercury in Powder Form. A. Galatzky, *Bull. soc. chim. France, 5,* No. 2, 1801-07 (1935). The preparation of the metal powder by the reduction of aqueous suspensions of mercurous oxide by hydrazine is described.

(825) The Reduction of Iron Ore Under High Pressure. E. Diepschlag, *Arch. Eisenhüttenwesen, 10,* 179-81 (1936). The effect of high pressure on the rate of reduction of iron oxide is shown.

(826) Sponge Iron Experiments At Mococo. C. G. Maier, *Bur. of Mines, Bulletin No. 396,* 1936, 81 pp. Principles of the reduction process; operating data; commercial utilization; economic problems; criticism.

(827) Chemical Methods of Producing Metal Powder for Industrial Use. P. Weissner, *Chem. Ztg., 60,* 536 (1936). A review of various processes, including precipitation and reduction.

(828) The Hydride Process – I. P. P. Alexander, *Metals & Alloys, 8,* No. 9, 263-64 (1937). New Hydrides Discovered; production and properties of calcium hydride; reduction of refractory oxides.

(829) Reduction of Chromium Oxide with Hydrogen and Carbon. W. Baukloh and G. Henke, *Z. anorg. allgem. Chem., 234,* 307-310 (1937). The reduction of Cr_2O_3 starts at 1000° C. (1830° F.), but the reduction temperature can be lowered by about 200° C. (360° F.) by the presence of iron powder.

(830) Reduction of Nickel and Copper Oxides. W. Baukloh and F. Springorum, *Z. anorg. allgem. Chem., 230,* 315-320 (1937). The oxides of copper are reduced more easily by carbon than the oxides of nickel.

(831) The Reduction of Manganese Oxide with Carbon in Vacuum. W. Baukloh and O. Ziepell, *Z. anorg. allgem. Chem., 233,* 424-428 (1937). The reduction of manganese oxide with carbon in vacuum, *e.g.*, at 1150° C. (2100° F.), to the metal powder is described.

(832) Reduction of Titanium Dioxide with Atomic Hydrogen. K. Iwase and N. Nasu, *Kinzokuno-Kenkyu, 14,* 87-90 (1937). The reaction is described.

(833) Reduction of Tungsten Oxide. W. Baukloh and F. Jaeger, *Z. anorg. allgem. Chem., 239,* 365-368 (1938). The reduction of tungsten oxide with carbon starts at 800° C. (1470° F.); that with hydrogen at 450° C. (840° F.).

(834) The Sponge Iron Process. K. Kusaka, *Tetsu-To-Hagane, 24,* 1077-85 (1938). Reduction temperature is 1000° C. (1830° F.) for tube, rotary and industrial rotary furnaces. Study of size ore, roast, natural gases, flow, temperature and catalysis.

(835) Pure Iron Powder. A. H. Allen, *Steel, 104,* No. 15, 43-54 (1939). Five different types of reduction, including low temperature reduction of iron oxides, are discussed.

(836) X-Ray Investigation of the Products of Reduction of Titanium Dioxide. E. Belyakova, *Metallurg, 14,* No. 4-5, 23-25 (1939). Experiments on reduction of titanium dioxide with hydrogen and carbon within temperature range of 1200-1500° C. (2190-2730° F.). Study of nature of reduction products by use of Debye powder method: Ti_2O_3 and TiO. Data on TiC as obtained by reduction in carbon monoxide atmosphere.

(837) Decarburization of Granulated Pig Iron; the "R.K. Process." B. Kalling and I. Rennerfelt, *Jernkontorets Ann., 123,* 115-54 (1939); *Iron & Coal Trades Rev., 89,* 359 (1939). Granulated Fe is continuously fed in a rotary furnace and decarburized without melting in a gaseous mixture of CO and CO_2 in such proportion that no surface oxidation takes place.

(838) Decarburization of Granulated Pig Iron. B. Kalling and I. Rennerfelt, *J. Iron Steel Inst., 140,* No. 2, 137-160 (1939). The "R.K." process is described.

(839) The Rennerfelt-Kalling Process for Production of Iron Granules. B. Kalling and I. Rennerfelt, *Stahl u. Eisen, 59,* 1077-1082 (1939). The theory and practice of the decarburization of the oxide, the influence of impurities and of the grain size, and the plant in Fagersta are discussed.

(840) The Production of Iron, Copper and Nickel Powders by Reduction of the Oxides (in Russian). I. P. Kislyakov, *J. Applied Chem. (U. S. S. R.), 12,* No. 11, 1668-1677 (1939). Report on experimental study of optimum conditions for producing powdered metals.

(841) Investigation of the Conditions of Titanium Carburization. G. A. Meerson and Ya. M. Lipkes, *J. Applied Chem. (U. S. S. R.), 12,* 1759-1767 (1939). In the production of TiC from TiO_2, it is believed that the reaction takes place in two stages, the first a reduction of TiO_2 to TiO, and the second, the formation of TiC from TiO.

(842) Special Furnace for Tungsten Powder Production. J. Murphy, *Heat Treating and Forging, 25,* 410-11 (1939). Description of furnace used by Mills Alloys, Inc., to reduce W-trioxide to tungsten powder.

(843) Reducing Iron Ores Under Pressure by Hydrogen. M. Tenenbaum and T. L. Joseph, *Trans. Am. Inst. Mining Met. Engrs., 135,* 59-72 (1939). Cubes of iron ore are reduced by H under comparable conditions at several pressures. Pressures greater than 10 in. of Hg increased the rate of reduction. The results are in agreement with the theory given in the paper.

(844) Simultaneous Reduction of the Oxides of Iron, Titanium, and Columbium with Aluminum. G. S. Kreimer, *J. Applied Chem. (U. S. S. R.), 13,* 1267-1270 (1940). Aluminothermic smelting experiments on laboratory and pilot-plant scale on mixtures of titanium oxide and columbium oxide (29% Cb_2O_5 and 58% TiO_2; 15% Cb_2O_5 and 57% TiO_2). Data on alloys and yields obtained. Correlation of experimental results with theory. Two-stage nature of reduction of TiO_2 with aluminum. Suitability of resulting alloys for the alloying of steel.

(845) Reduction of Oxides of High-Melting Metals with Calcium Hydride. G. A. Meerson, G. A. Kats and A. V. Chochlova, *J. Applied Chem. (U. S. S. R.), 13,* 1770-1776 (1940). Experimental study of optimum conditions of production of Ti, V, Cb, and Ta with calcium hydride as reducing agent. Review of production processes described in literature. Procedure and apparatus used. Reduction of titanium dioxide. Reduction of vanadium trioxide. Reduction of columbium pentoxide. Reduction of tantalum pentoxide.

(846) Sponge Iron. S. Novakovskii and L. I. Ponirovskaya, *Trudy Inst. Khim. Kharkov, Gasudarst Univ., 5,* 293 (1940). Low temperature reduction of iron oxide is reported.

(847) Reduction of Iron Ores Under Pressure by Carbon Monoxide. M. Tenenbaum and T. L. Joseph, *Trans. Am. Inst. Mining Met. Engrs., 140,* 106-125 (1940). Features of reduction process, experimental work, reduction of cubes of Fe-ore, application of kinetics to experimental results.

(848) Reduction of Iron Ore. M. Wiberg, *Jernkonterets Ann., 124,* 179-186 (1940). A reduction to the core of the particles is possible only with a highly porous ore.

(849) Reducing Iron Ore with Hydrogen. M. H. Kalina and T. L. Joseph, *Iron Age, 148,* No. 24, 39-43 (1941). Manufacture of high grade powder from the ore is described. The manner in which reduction of lumps of ore progresses from the outside toward the interior is determined.

(850) Laboratory Method for Zinc Dust Precipitation of Cyanide Solutions. S. J. McCarroll, *Eng. Mining J., 142,* 39-40 (1941). Apparatus and method illustrated and described.

(851) Investigation of the Conditions of Titanium Carburization. G. A. Meerson and Ya. M. Lipkes, *J. Applied Chem. (U. S. S. R.), 14,* No. 3, 291-301 (1941). Authors' theory based on thermodynamic considerations, regarding influence of degree of dispersion of carbon upon carburizing process. Agreement between this theory and results of experiments. Best rate of heating under industrial conditions for maximum combined carbon content (19-19.5%) of titanium carbide. Reasons for nonuniformity and poor quality of industrial titanium carbide.

(852) Sponge Iron. *Engineer (London), 174,* No. 4519, 155; No. 4523, 235 (1942). Refers to experiments of U. S. Bureau of Mines having shown the feasibility of reducing iron ore directly with natural gas or coal.

(853) Hydride Process and Its Products. P. P. Alexander, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942. Chapt. 12, pp. 145-154 (1942). Discussion of production of metal and metal hydride powders, such as titanium, active metals, powdered alloys, their properties, handling, stability.

(854) R. Durrer, *Die Metallurgie des Eisens,* Verlag Chemie, Berlin, 1942. On pp. 410 ff. the reduction processes used to obtain sponge iron from iron oxides are treated in detail; on pp. 456-458 the Rennerfelt-Kalling ("R-K") process based on the decarburization of granulated pig iron is described.

(855) Reduction of Iron Oxides Under Pressure. E. Edwin, *Tids. Kjemi Bergvesen Met., 2,* 23-31 (1942). A new sponge iron process in Norway, the "Norsk-Staal" process, employs lime in addition to solid carbon and a closed pressure vessel for the reduction. Details of laboratory experiments and pilot plant trials and their results are reported.

(856) Reduction of Iron Oxides Under Pressure. E. Edwin, *Stahl u. Eisen, 63,* 180 (1943). The process employs lime in addition to solid carbon and a closed pressure vessel for the reduction.

(857) The Use of Rolling Mill Scale in Powder Metallurgy. F. Eisenkolb, *Kolloid-Z., 104,* No. 2/3, 236-46 (1943). Reduction of ground rolling mill scale with the proper amount of charcoal gives an iron powder that can be used in metallurgy. Subsequent treatment with hydrogen will further improve product.

(858) Reduction of Iron Ore under Pressure. L. Heller, *Stahl u. Eisen, 63,* 180 (1943). A report on the article of E. Edwin in item **855** above describing a new method for the production of sponge iron.

(859) Production of Sponge Iron. E. Améen, *Iron & Coal Trades Rev., 148,* 211, 249 (1944). The Wiberg reduction process at Söderfors is described.

(860) An Experiment in Making Sponge Iron. W. E. Brown, *Eng. Mining J., 145,* No. 11, 83-86 (1944). Process used in Madaras Steel Corp., Texas Works, for making sponge iron by direct reduction of iron ore is described.

(861) Reduction of Metal Powders. J. E. Drapeau, *Iron Age, 153,* No. 22, 55 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Particles of Cu-oxide and Fe-oxide are examined under high magnification in the furnace while reduced. Evaluation of the optimum temperature for the reduction to avoid excessive sintering.

(862) Thermodynamic Properties of Carbides of Chromium. K. K. Kelley, F. S. Boericke, G. E. Moore, E. H. Huffman and W. M. Bangert, *U. S. Bur. Mines, Tech. Paper No. 662,* 43 pp. (1944). It was found that the carbon reduction of CrO takes place in four distinct, reversible reaction steps; results of equilibrium measurements are reported for each reaction step.

(863) Höganas Sponge Iron Process. S. Eketorp, *Jernskontorets Ann., 129, No. 1* 703-10 (1945); *Iron Steel Inst. London, Transl. No. 275,* July, 1946; *Met. Powd. Rept., 1,* No. 1, 4 (1946). The process involves the use of very high-grade magnetic concentrate which is packed in ceramic containers with altering layers of coal, heated to 1200° C. (2190° F.) in a furnace of the type used in the production of firebrick.

(864) Producing Sponge Iron in Rotary Kiln. T. L. Johnston, *Steel, 117,* No. 20, 128-29, 140, 142 (1945). Pilot plant, operated by Bureau of Mines, employs coal to reduce iron in the ore to metallic form. Details of the process are described.

(865) Calcium Metallurgy and Technology. C. L. Mantell and C. Hardy, *Am. Chem. Soc. Monograph No. 100,* Reinhold, New York, 1945. Book covers properties and production of Ca, which is used as reducing agent in production of certain metal powders.

(866) Investigation of the Conditions of Titanium Carburization. G. A. Meerson and Ya. M. Lipkes, *J. Applied Chem. (U. S. S. R.), 18,* No. 4/5, 251-258 (1945). A description is given of the thermodynamic calculations of the process based on the reaction $TiO + 2C = TiC + CO$.

(867) Production of Sponge Iron in a Shale Brick Plant. D. W. Ross, *U. S. Bur. Mines, Rept. Invest. 3822,* 1945. Reduction in a tunnel kiln, and reduction in periodic down-draft kiln are reported on.

(868) Manufacture of Sponge Iron in Periodic Brick Kilns. K. M. Smith and S. E. Burton, *U. S. Bur. Mines, Rept. Invest. No. 3841,* 1945, 38 pp. A process similar to the Höganas process was employed at a brick plant in Canton, Ohio. Saggers are charged with anthracite, limestone, and an extruded piece of Fe ore.

(869) The Low-Temperature Gaseous Reduction of Magnetic Ore to Sponge Iron. O. G. Specht, Jr. and C. A. Zapffe, *Trans. Am. Inst. Mining Met. Eng., 167,* 237-280 (1946). Examination of previous work; experimentation on the reduction of magnetite with hydrogen; development of thermodynamic relationships in reduction bibliography.

(870) Krupp-Renn Process for Low Grade Iron Ores in Germany. P. M. Tyler and W. M. Pollitzer, *F. I. A. T. Rept. No. 799,* 1946. Reports on reduction processes for sponge iron; Krupp-Renn process; washing and gravity concentration; and Lurgi process.

(871) Improvements in Powder Metallurgy. *Chem. Age (London), 57,* No. 1465, 192 (1947). A discussion of British Patent Applications 13370/1947 by General Motors Corp. for reducing a mixture of mill scale and carbon alloy powder to iron.

(872) Profitable Impalpable. *Ind. Eng. Chem. Ind. Ed., 39,* No. 9, 8A (1947). Acid-solution process recently brought into production for converting machine-shop steel scrap into high purity powdered iron.

(873) Investigation of Bubble Hearth Process for Production of Sponge Iron. E. P. Barrett, C. E. Wood, V. Miller, W. E. Brown, P. R. Porath and C. Prasky, *U. S. Bur. Mines Rept. Invest. No. 4092,* 1947. The reduction furnace and the experimental work are described.

(874) Deposition of Nickel, Cobalt and their alloys by Chemical Process. A. Bremer and G. Riddell, *J. Research Natl. Bur. Standards, 39,* 385-399 (1947). Data presented on deposition of nickel, cobalt and their alloys from hot hypophosphite solutions without use of electrical current.

(875) Production of Low-Sulfur Sponge Iron. R. C. Buehl, E. P. Shoub and J. P. Riott, *Trans. Am. Inst. Mining Met. Engrs., 172,* 76-85 (1947). The existence of a basic layer containing all the sulfur in the surface of sponge iron articles, which are produced from a mixture of ore, reducing agent, lime or dolomite, has been established.

(876) Control of Sulfur Content of Sponge Iron. R. C. Buehl, E. P. Shoub, and J. P. Riott, *U. S. Bureau Mines Rept. Invest. No. 4057,* 1947, 102 pp. Sponge iron with 0.06% S produced in an internally fired kiln. One means is addition of 5-15% dolomite. Reducing temperature 890-940° C. (1800-1900° F.).

(877) Reduction in Carbon, Sulfur, Oxygen Contents of Iron Powder during Sintering. G. F. Hüttig, *Arch. Metallkunde, 1,* No. 7/8, 359-361 (1947). Experiments made on mixture of iron powder and cast iron powder. C, O, S contents were plotted against sintering temperature (300-1300° C.; 570 - 2370° F.) both for loose powders and compacts. Addition of $FeCl_2$ results in elimination of O, C at 700-800° C. (1290-1470° F.) instead of at 1100° C. (2010° F.) but does not accelerate sulfur removal.

(878) The Losses in Carbon, Sulfur and Oxygen during Sintering of Iron Powders. G. F. Hüttig and K. Sedlatschek, *Powd. Met. Bull., 2,* No. 4, 80-84 (1947). Results of experiments indicate that heating in hydrogen at temperatures below 500° C. (930° F.) lowers O content without markedly decreasing C content. It must be expected that low temperature reduction will not result in complete elimination of O, since O is present in form of oxide inclusions.

(879) Experiments on Reducing the Silica Content of Mill Scale. H. Kassner, H. E. C. Docum. No. 12186, 1947. Treatment with alkali solutions. The Linz process consists of reducing the ground and cleaned mill scale with coke dust in form of briquettes.

(880) Preparation of Metallic Powders. R. Lautie, *Bull. soc. chim. France, 14,* No. 5, 974-977 (1947). Reduction of oxide of metals with potassium was studied; vapors of potassium react with metal compound, freeing the metal, which is distilled and condensed as powder.

(881) Rate of Reduction of Rolling Mill Scale. H. Ley and H. Kassner, F. D. Rept. No. 5027/47 (1947) (formerly H. E. C. 12167). Laboratory experiments at the Metallgesellschaft in 1940 showed that with hydrogen a working temperature of 700-800° C. (1290-1470° F.) was necessary. Further experiments were made with partially burnt coke-oven gas, in the presence of 0.1% soda as catalyst.

(882) Plant for Carbide Scrap Recovery. Studiengesellschaft Hartmetall. F. D. Rept. No. 3863/47 (1947). Discussion in 1941 with Siemens and Halske regarding construction of an electrolytic plant for recovery of tungsten from carbide scrap by chemical processes.

(883) Metal Recovery from Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3866/47 (1947). According to this report of 1941, scrap WC-Ni was carburized at 1600° C. (2910° F.) and leached with HCl; W and Ni were recovered.

(884) Metal Recovery from Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3869/47 (1947). According to this report dating back to 1941, 80% cobalt was recovered from 15 tons of scrap carbide by treatment with HCl followed by NaOH and Na_2CO_3.

(885) Calcium Tungstate. Studiengesellschaft Hartmetall. F. D. Rept. No. 3871/47 (1947). Reduction of calcium tungstate with boiling HCl is described in this report of 1941.

(886) Recovery of Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3894/47 (1947). Experience obtained by 1941 with the sodium nitrite process of recovering scrap carbide.

(887) Swedish Sponge Iron. M. Tigerschiöld, *Metals Technol., 14,* No. 5, T. P. 2188 (1947). Discussing paper of Buell, Shoub and Rioti, *Trans. Am. Inst. Mining Met. Engrs., 172,* 76-85 (1947) on the production of low-sulfur sponge iron.

(888) Use of Sponge Iron for Steel in Sweden. M. Tigerschiöld and S. Eketorp, *Proc. Conf. Am. Inst. Mining Met. Engrs., 6,* 1947; *Blast Furnace, Coke Oven and Raw Mat., 177,* 94-101 (1947). In the Högenas process the C content is below 0.1%, while in the Wiberg process Fe can take up 0.7% C. The two processes are analyzed.

(889) Sponge Iron in Japan. *U. S. Bur. of Mines, Inform. Circ. No. 7440,* 1948. Rotary-kiln method is most important; using a mixture of 100 parts iron ore, 56 parts anthracite, 10 parts limestone, reaction yielded pellets of iron mixed with slag. In the Kikuchi method a high-frequency current passes through the mixture of iron ore, coal and limestone.

(890) Production of Sponge Iron. E. P. Barrett and C. E. Wood, *U. S. Bur. Mines, Rept. Invest. No. 4305,* 1948, 19 pp. Gaseous reduction of iron oxide glomerules in a shaft furnace; but the reduction could not be completed in hot H_2 unless the column was heated externally.

(891) Reduction of Iron Ores by Natural Gas. C. Candea, *Met. Powd. Rept., 3,* No. 1, 12 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 178 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 47. Finely ground iron ore can be reduced to metallic powder without carburization by using partially cracked methane at 1000° C. (1830° F.).

(892) Peculiarities of the Silicothermic Reduction of Metals. P. V. Gel'd, *Doklady Akad. Nauk. S.S.S.R., 61,* 495-498 (1948). Study of reasons for the poor utilization of silicon in the reduction of metal oxides by silicon, *e.g.,* in production of carbon-free ferrochromium and certain other ferroalloys. Experimental procedure and results are given. Similarity between silicothermic and aluminothermic reactions is described.

(893) Tantalum Powder by Magnesium Reduction. J. P. Isaza, A. J. Shaler and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 175,* 784-90 (1948). Simple method for making metal powder from volatile compounds of refractory metals has been applied to Ta and Cb.

(894) Reduction of Rolling Mill Scale with Solid Reducing Agents. H. Kassner and E. Schnitzspahn, F. D. Rept. No. 670/48 (1948) (formerly H. E. C. 12198). Laboratory results in 1940 obtained with wood charcoal, peat coke and various patented carbon products.

(895) Reduction Rates of Iron Oxide and Mill Scale. H. Ley, F. D. Rept. No. 670/48 (1948) (formerly H. E. C. 12224). The retarding effect of water vapor was investigated in 1940.

(896) Studies on Production of Metal Powders by Reduction of Aqueous Solutions. E. Pelzel, *Met. Powd. Rept., 3,* No. 1, 10 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 179 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 44. By reducing copper sulfate solution with alloy powders, having the composition of intermetallic compounds, the reaction was impeded by the formation of Cu coatings; but by regulating the particle size of the reducing powder it was possible to obtain Al bronze and brass.

(897) Precipitation of Metals from Solution by Metals. N. A. Snoorovskaya and O. K. Budnikova, *Izvest. Akad. Nauk. SSSR. Otdel. Tekh. Nauk, 131* (in Russian); *C. A., 42,* 6293 (1948). Displacement of metals from solution cyanide of Au by Zn is mainly determined by the rate of diffusion; this is demonstrated by the temperature dependence of the process, and by the effect of stirring. The degree of precipitation increases with the concentration of NaCN.

(898) The Aluminothermic Process and the Preparation of Pure Chromium, Manganese, and Ferro-Columbium. T. Burchell, *Symposium on Refining of Non-Ferrous Metals,* Institute of Mining and Metallurgy, 1949, Paper No. 15, 20 pp. The author explains the importance of particle size and of methods employed for adjusting the oxygen ratio, *i.e.,* the ratio of oxygen in the ore to the aluminum powder.

(899) Commercial Production of Sponge Iron. P. E. Cavanaugh, *Iron Age, 163,* No. 22, 67-71, 82 (1949). Test runs conducted in Sweden, employing the Wiberg-Soderfors process, have indicated the excellent performance of Canadian Steep Rock ore and the high production rates. Operating and cost data, converted to Ontario conditions, are presented.

(900) Manufacture of Sponge Iron. B. Kalling and J. Stalhed, *Steel, 125,* No. 12, 72-5, 102, 106 (1949). The Wiberg-Soderfors process is described. It requires less reducing agent than other reduction processes.

(901) Contribution to the Theory of the Hydrogen Reduction of Magnetite (in German.) M. Tikkanen, *Valtion Teknillinen Tutkimuslaitos* (State Inst. for Technical Research, Finland), *Publication No. 12,* 1949, 92 pp. A description is given of some fundamental laboratory work, done partly under Prof. J. A. Hedvall at the Chalmers Tech. College, Göteborg, and partly at the Husqvarna Vapenfabrik, Husqvarna, Sweden. The difficulties encountered in the reduction of magnetite with hydrogen at 600-900° C. (1100-1650° F.) is attributed essentially to the obstacle caused by the removal of water vapor.

D. Electrical Processes (electrolysis, dispersion, sputtering)

(902) The Phenomenon of the Formation of Metallic Dusts from Cathodes. F. Haber, *Trans. Am. Electrochem. Soc., 2,* 189-196 (1902). Found metallic dusts from cathodes during electrolysis, caused mainly by sodium or potassium, if in large proportion in the anode alloy material.

(903) Electrolytic Reduction of Titanium Sulfate. B. Diethelm and F. Foerster, *Z. physik. Chem., 62,* 129-77 (1908). An investigation of the electrolytic reduction.

(904) Electrometallurgical Procedure for the Working Up of Zinc Dust and Scrap Metal to Pure Metal. H. Paweck, *Z. Elektrochem., 27,* 16-21 (1921). Formation of an anolyte with 4% Zn, and a catalyte with 10% Zn by mixing Zn with diluted H_2SO_4; the solution is electrolyzed as long as the catalyte has only 4% Zn, whereby H_2SO_4 is set free.

(905) Precipitation of Tungsten from Its Salt Solutions. B. Neumann and H. Richter, *Z. Elektrochem., 30,* 474-77 (1924). Small deposits of tungsten were obtained from the electrolysis of solutions of tungsten hexachloride in glycerine. The efficiency of the method is very low.

(906) The Formation of Copper Powder at the Anode, and the Passivity of the Anodes. E. Denina, *Ann. chim. applicada, 17,* 284-96 (1927). A detailed discussion, based on physical chemistry principles and mathematical reasoning in which the mechanism of the process is explained shows the favorable influence of a high current density in minimizing the loss of Cu in the anode sludge.

(907) Electrolytic Deposition of Tungsten at a Mercury Cathode. K. S. Jackson, A. S. Russell and J. L. Merrill, *J. Chem. Soc. (London), 1929,* 2394-2401. A description is given of the electrolytic deposition of tungsten powder at a mercury cathode. The conditions for the electrolysis and the yield of the product are discussed.

(908) Electrolytic Preparation of Thorium and Uranium. F. H. Driggs, *Eng. Mining World, 1,* 477-479 (1930). An uranium bath is obtained by treating uranium nitrate with potassium fluoride, hydrofluoric acid and formic acid in the presence of ultra-violet light, to obtain potassium uranium fluoride, which is dissolved in a fused mixture of calcium and sodium chloride. Thorium is prepared in analogous manner.

(909) Preparation of Metal Powders by Electrolysis of Fused Salts: I: Ductile Uranium. F. H. Driggs and W. C. Lilliendahl, *Ind. Eng. Chem. Ind. Ed., 22,* 516-19 (1930). Electrolysis of KUF_5 described; electrolyte is 250 g. NaCl, 250 g. $CaCl_2$ melting at about 625° C. (1150° F.) to which about 30 g. KUF_5 are added; electrolysis at about 775° C. (1430° F.) with 30 amps., 5 volts.

(910) Preparation of Metal Powders By Electrolysis of Fused Salts: II. Thorium. F. H. Driggs and W. C. Lilliendahl, *Ind. Eng. Chem. Ind. Ed., 22,* 1302-3 (1930). Electrolysis of $KThF_5$ described; electrolyte 500 g. NaCl, 500 g. KCl, 64 g. $KThF_5$; electrolysis at about 750-775° C. (1380-1430° F.).

(911) Studies in the Electrodeposition of Metals. D. B. Keyes and S. Swann, *Univ. Illinois Eng. Expt. Station, Bull. 206,* 1930. The electrodeposition of Al, Be, Co, Ti, V, Cr, and W are investigated.

(912) Preparation of Metal Powders by Electrolysis of Fused Salts: III: Tantalum. F. H. Driggs and W. C. Lilliendahl, *Ind. Eng. Chem., 23,* 634-37 (1931). Electrolysis of K_2TaF_7; electrolyte 700 g. KCl, 280 g. KF, 100 g. K_2TaF_7, 100 g. Ta_2O_5 as starting charge, then 400 g. KCl, 80 g. KF, 110 g. K_2TaF_7, 100 g. Ta_2O_5 as second charge; electrolysis at about 750° C. (1380° F.) with 45 amps.

(913) Electrolysis in Fused Phosphates. H. Hartmann, F. Ebert and O. Bretschneider, *Z. anorg. allgem. Chem., 198,* 116-140 (1931). Metallic tungsten is electrodeposited from a bath of fused phosphates of sodium. Two different crystal modifications are obtained, depending on the temperatures employed.

(914) Powdered Metals by Electrolytic Methods. J. Rossman, *Metal Ind. (N.Y.), 30,* 321-22, 396-97, 436, 486-89 (1932). Review of patents.

(915) Electrodeposition of Ti with Hg Cathode (in English). S. Zeltzer, *Collection Czechoslovak Chem. Commun., 4,* 319-34 (1932). An investigation with the dropping mercury cathode is described.

(916) Electrolytic Production of Tungsten from Fused Phosphate Bath. S. Leo and T. Shen, *Trans. Electrochem. Soc., 66,* 461-69 (1934). The optimum conditions of temperature, current density and bath composition are given for the deposition of tungsten from a fused bath of sodium phosphates.

(917) Method for Production of Dispersed Metals. B. Claus, *Z. tech. Physik, 16,* 80-82, 202-05 (1935). Description of production of metal powders such as Fe, Ag, and Pt by electrodeposition under the influence of ultrasonic waves.

(918) Electrodeposition of Thin Layers of Titanium. M. Haïssinsky and H. Emmanuel-Zavizziano, *Compt. rend., 204,* 759-61 (1937). The titanium is electrodeposited on a Pb cathode from an aqueous solution of $Ti_2(SO_4)_3$ containing Na_2SO_4.

(919) Electrochemical Studies of Titanium. M. Haïssinsky and H. Emmanuel-Zavizziano, *J. chim. phys., 34,* 641-8 (1937). Survey of conditions for depositing Ti from $Ti_2(SO_4)_3$.

(920) General Conditions Governing the Type and Structure of Cathode Metal Deposits. O. S. Fedorova, *J. Gen. Chem. (U. S. S. R.),* 8, 1711-6 (1938). Includes examples and conditions of electrolysis, particularly for the preparation of powdered nickel deposits.

(921) Current Density During the Electrolysis of Fused Salts. I. M. Dyakonov, *Tsvetnye Metal., 14,* No. 1, 89-91 (1939). Discussion of the preparation of nickel powder by electrolytic methods.

(922) Preliminary Experiments on the Electrodeposition of Titanium and its Alloys. N. N. Gratsians'kii and A. P. Vovkogon, *Zapiski Inst. Khim. Akad. Nauk, S. S. S. R., 7,* 173-77 (1940). Titanium is deposited on a copper cathode from an electrolyte of sulfanilic acid and $Ti(OH)_2$. From the fused bath $AlCl_3$-NaCl-NaF, a Zn-Ti alloy is deposited on copper and iron cathodes. Deposits may be in form of plates, sponges, or powder.

(923) Contribution to the Problem of Production of Metallic Titanium by Electrolysis of Nonaqueous Media. S. I. Sklyarenko and Ya. M. Lipkes, *J. Applied Chem. (U. S. S. R.), 13,* No. 1, 51-55 (1940). Laboratory experiments in search of an efficient technological process for metallic titanium. Review of literature on subject. Description of authors' experiments on electrochemical reduction of titanium dioxide in fused salts.

(924) Production of Metal Powders. M. Passer, *Kolloid-Z., 97,* No. 3, 272-280 (1941). Survey of the sponge-like deposits of metals on cathodes. Separation of Zn powder from solutions. Importance of the currents of gas and liquids.

(925) Powder Metallurgy and Its Relation to the Electroplating Industry. J. F. Kuzmick, *Proc. 31st Ann. Convention, Am. Electroplater's Soc.,* 1943, pp. 39-41. General discussion of powder metallurgy, especially electrolytic preparation of powders of pure metals and alloys.

(926) Investigation of Influence of Ultrasound upon the Electrodeposition of Copper and Zinc. T. Rummel and K. Schmitt, *Korrosion und Metallschutz, 19,* No. 4, 101-104 (1944). Experimental equipment and procedure. Electrodeposition of copper: variation of current efficiency as function of current density, with and without the use of ultrasound. Microexamination of deposits (plates, sponges, flakes, powders). Electrodeposition of zinc: evolution of hydrogen, effect of supersonic waves, pattern formation on both sides of cathode, in zinc plating.

(927) Review of Patents on Electrolytic Methods for Making Powdered Metals. J. Rossman, *Trans. Electrochem. Soc., 85,* 169-173 (1944). U. S. patent review of electrolytic powder manufacture.

(928) Metal Powders. *Metal Ind. (London), 67,* No. 4, 53, 55 (1945). Manufacture by electrodeposition and fused salt electrolysis discussed.

(929) Metal Powders. *Steel, 116,* No. 22, 114 (1945). Produced by fused salt electrolysis, for powder metal compacts. About 20 different metals have been deposited as small crystals or dendrites by this method.

(930) Metal Powders. W. J. Kroll, *Metal Ind. (London), 67,* No. 14, 214-16, 229-230 (1945). Production of pure metal powders or alloy powders by the fused electrolyte method is discussed. Removing adherent bath salts from the metal crystals is described.

(931) Fused Salt Electrolysis for Production of Metal Powders. W. J. Kroll, *Trans. Electrochem. Soc., 87,* 37-54 (1945). Method for removing adherent bath salts from metal crystals are discussed. Fundamental reactions taking place at cathode and at anode when solid metals or alloys are being deposited from fused salt bath.

(932) Fluoride Process of Production of Beryllium Compounds, Metals and Alloys. H. Kawecki, *Trans. Electrochem. Soc., 89,* 229-239 (1946). Electrolytic and electrothermal methods of reduction of Be oxide to metal and the fluoride process of producing Be oxide.

(933) Production of Iron Powder by Electrodeposition. G. E. Gardam, *Symposium on Powder Metallurgy.* The Iron and Steel Inst. Special Rept. No. 38, London, 1947, 3-7; *Met. Powd. Rept., 1,* No. 11, 161 (1947). A dendritic iron powder with 1% O was made in a pilot plant, at a rate of ¼ lb./hr., by electrolysis of 10% ferrous ammonium sulfate solution.

(934) Electrolytic Production of Tungsten-Cobalt, Tungsten-Nickel, and Tungsten-Iron Alloys. H. Offermanns and M. v. Stackelberg, *Metalloberfläche, 1,* No. 6, 142-144 (1947). Description of process for electrolytic production of alloys of iron,

cobalt and nickel containing up to 50% tungsten. Alloys may be deposited as sponges or powders.

(935) Preparation of Metal Powders by Electrolysis. *J. four élec., 57,* 12-17 (1948). Methods for separation of the crystals from the bath. Choice of the bath solution and of the material for anode, cathode, and diaphragm.

(936) Preparation of Metal Powders by Electrolysis. J. L. Andrieux, *Revue mét., 45,* No. 1, 49-59 (1948). Preparation of the metals; metal-metalloid binary compounds, silicides, arsenides, metallic carbides are discussed.

(937) Production of Electrolytic Metal Alloys by Means of Controlled Anodes. R. Müller and H. Krainer, *Met. Powd. Rept., 3,* No. 1, 10 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 179 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 34a. The electrolyte should contain ions roughly in the desired alloy ratio. Each anode is one of the alloying metals, with individual resistance control, and the electrolyte is stirred. The ratio of the two resistances is so adjusted that the cathode deposit is of the alloy required. Method applicable to production of alloy or composite powders or coherent deposits.

(938) A Simple Method of Preparing Magnetic Powder. L. Ya. Popilov, *Zavodskaya Lab., 15,* 491 (1949). Magnetic powder, for magnetic particle testing, is made by exposing electrodes of compacted iron or steel powder to a powerful arc discharge under water, one of the electrodes being vibrated electromagnetically.

E. Miscellaneous Processes (diffusion, sintering, alloy disintegration)

(939) Nature of Nickel-Chromium Rustless Steels. E. C. Bain and R. H. Aborn, *Trans. Am. Soc. Steel Treating, 18,* 837-93 (1930). On p. 877 is found a discussion of the corrosion method for the production of alloy powder.

(940) Precipitation of Carbides of Stainless Steel. B. Strauss, H. Schottky, and J. Hinnüber, *Z. anorg. allgem. Chem., 188,* 309-324 (1930). "Strauss reagent," consisting of 11% $CuSO_4$, 10% H_2SO_4, and the remainder water, will disintegrate pre-annealed bulk stainless steel into powder. The annealing precipitates carbides in the grain boundaries of the materials, making them subject to attack by the corrosion agent.

(941) Stainless Steel Powder. J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 11, pp. 137-144. The chemical disintegration method, involving sensitizing the grain boundaries of stainless steel sheet or scrap by elevated temperature carburization followed by chemical dissolution of the carbide regions with Strauss reagent (11% $CuSO_4$, 10% H_2SO_4, bal. water), is described. Method is applicable to 18-8 stainless steel, sulfur-containing nickel-iron alloys, Muntz metal (60-40 Cu-Zn), and more complex stainless steels.

2. METHODS AND EQUIPMENT FOR MANUFACTURING SPECIFIC COMPOSITIONS FOR POWDERS

A. Metal Powders (refractory, precious and rare, ferrous, non-ferrous, low melting, light-metal)

(942) Eraclius. *De Coloribus et Artibus Romanorum*, 994 (Latin Text edited by Albert Ilg, with German Translation in *Quellenschriften für Kunstgeschichte und Kunsttechnik des Mittelalters und der Renaissance*, 1873, pp. 4 ff. A description is given of the methods used for the production of gold and silver powders in 994 A. D.

(943) J. J. De Lhuyart and F. De Lhuyart, *Analisis Quimico del Wolfram y Examen de un Nuovo Metal que Entra in su Composicion.* Vascongada, 1783. A description is given of the production of tungsten from tungstic oxide by reduction with coal.

(944) Tungsten and Its Alloys. E. Zettnow, *Poggendorffs Ann., 130,* 16-49 (1867). Metallic tungsten powder was obtained by electrolytic reduction.

(945) M. Berthelot, *Introduction a l'Étude de la Chimie des Anciens et du Môyen Age*, Paris, 1889. Gold powder production is discussed on pp. 31-33. A translation of an Egyptian Greek manuscript of 300 A.D. describes the manufacture of gold powders by direct mechanical disintegration and by heating gold amalgams.

(946) Production of Chromium from Potassium Chrome-Chloride and Magnesium. E. Glatzel, *Ber., 23,* 3127-30 (1890). The production of chromium powder by the reduction of $CrCl_3$ with Mg plus KCl addition is described.

(947) Electrolytic Iron. C. F. Burgess and C. Hambuechen, *Trans. Am. Electrochem. Soc., 5,* 201-210 (1904). The electrolysis of a weak acid solution of ferrous sulfate, ammonium sulfate and ammonium chloride for the production of iron powder is described.

(948) Production of Ductile Iron. *Z. Elektrochem., 15,* 595-96 (1909). A report is made of a plant erected by Langbein-Pfannhauser and Siemens and Halske to produce 200 tons per month of electrolytic iron powder using fused salts.

(949) Metallic Titanium. M. A. Hunter, *J. Am. Chem. Soc., 32,* 330-6 (1910). Deals with production of Ti in form of a powder or sponge by reducing $TiCl_4$ with Na.

(950) Zinc Dust Precipitation Tests. N. Herz, *Trans. Am. Inst. Mining Met. Engrs., 52,* 138-46 (1916). Impurities in Zn dust; screen analysis; substitutes for Zn dust. Conclusions.

(951) Electrolytic Zinc Dust. H. J. Morgan and O. C. Ralston, *Trans. Am. Electrochem. Soc., 30,* 229-39 (1916); *Met. Chem. Eng., 15,* 465-8 (1916). A method is described whereby the powder is produced by depositing a sponge metal from solutions by electrolysis; it is possible to get a zinc product that on drying crumbles into zinc dust.

(952) Zinc Dust. O. Ravner, *Tek. Ukeblad, 67,* 404-8, 418-20 (1920). Influence of foreign gases on the formation of zinc dust during the condensation of zinc vapors.

(953) Metallic Titanium. L. Weiss and H. Kaiser, *Z. anorg. allg. Chem., 65,* 345-402 (1920). An amorphous form of Ti is produced by reduction of K_2TiF_6 with Na.

(954) Titanium. M. Billy, *Ann. chim., 16,* 5-54 (1921). Pure Ti in form of a powder or sponge is produced by passing $TiCl_4$ vapors over NaH.

(955) Condensation of Zinc Vapor. O. Ravner, *Chem. Met. Eng., 24,* 885-886 (1921). The zinc retort and a separate condenser were maintained under close temperature control, and the amount of Zn dust was determined.

(956) Preparation of Antimony Compounds. O. Hönigschmid, E. Zintl, and M. Rinhard, *Z. anorg. Chem., 136,* 265-82 (1924). Antimony powder is obtained by hydrogen reduction at 500° C. (930° F.) of antimony tetroxide, or the lower antimony oxides.

(957) Manufacture of Pure Tungsten. G. A. Percival, *World Power, 4,* 11-19 (1925). By wet treatment of sodium tungstate a pure oxide is obtained in a mechanical form suitable for reduction to metallic powder.

(958) The Electrolytic Deposition of Tungsten. J. A. M. Van Liempt, *Z. Elektrochem., 31,* 249-55 (1925). Description of production of tungsten powder by fusion-electrolysis of alkali tungstates (*e.g.*, lithium tungstate) at 900° C. (1650° F.) and higher temperatures through formation of so-called "tungsten-bronzes."

(959) Formation of Powdered Copper in Anode Mud. M. Thompson, *Chem. Met. Eng., 33,* 298-299 (1926). The usual explanation of the precipitation of finely divided metal at the anode is shown to be incorrect.

(960) The Manufacture of Nickel by the The Mond Nickel Co. Ltd. *J. Soc. Chem. Ind., 46,* 386-91 (1927). The furnaces and processes used for the production of nickel powder by the carbonyl process are described.

(961) Electrochemical Studies of Titanium. E. D. Botts and F. C. Krauskopf, *J. Phys. Chem., 31,* 1404-19 (1927). Ti is produced in form of a powder or sponge by reduction of $TiCl_4$ with Na.

(962) Sponge Iron. A. Johansson, *Jernkontorets Ann., 111,* No. 4, 51-59 (1927). A description is given of the Wiberg process of producing sponge iron, and the winning of iron powder as a by-product is cited.

(963) Preparation of Compacts and of Colloidal Molybdenum. E. Wedekind and O. Jochem, *Z. angew. Chem., 40,* 434-38 (1927). Compacts weighing up to 8 g. may be obtained by heating a mixture of Mo trioxide or dioxide with calcium shavings in vacuo. Colloidal Mo is obtained by heating a mixture of the oxides with Zn powder.

(964) The Production of Sponge Iron. C. E. Williams, E. P. Barrett and B. M. Larsen, *Bur. of Mines Bull. No. 270,* 1927, 175 pp. The following subjects are presented: sponge iron processes and furnaces; reduction of iron oxides; determination of metallic and ferrous iron in sponge iron; reducing atmospheres and agents, and effects of temperature and of stirring.

(965) Iron Carbonyl and Carbonyl Iron. A. Mittasch, *Stahl u. Eisen, 48,* No. 29, 979-80 (1928). A description is given of the preparation, properties and uses of iron carbonyl, and of the preparation, constitution and uses of iron powder prepared from it.

(966) Preparation of Pure Tungsten. Y. Nakazawa and T. Okada, *Elec. Rev. Japan, 17,* 89 (1928); *J. Inst. Metals, 42,* 411 (1928). The degree of the hydration of tungstic acid for the preparation of pure W powder is determined with concentrated hydrochloric acid solution by different methods.

(967) Compressed Powder Permalloy. W. J. Shackleton and I. G. Barber, *Trans. Am. Inst. Elect. Engrs., 47,* No. 2, 429-39 (1928). The electrolytic deposition of a fine, friable iron powder saturated with hydrogen is described.

(968) Preparation of Pure Uranium. E. Botolfsen, *Bull. soc. chim. France, 45,* 626-628 (1929). U_3O_8 is reduced by heating with purified calcium in an evacuated vessel. The reduced product is sieved and washed, so that uranium powder results.

(969) Preparation of Molybdenum. H. J. Braun, *Metallbörse, 19,* 2190-2192 (1929). A powdery or spongy mass of the metal is obtained by firing a Thermit mixture of 100 g. Mo trioxide, 38 g. Al powder, 50 g. calcium fluoride in a crucible, which is placed inside a larger crucible containing a Fe Thermit mixture.

(970) The Chemistry of Tantalum. V. Spitzin and L. Kaschtanoff, *Z. anorg. allgem. Chem., 182,* 207-27 (1929). Tantalum powder was produced by sodium reduction of K_2TaF_7. By the reaction of Mg on tantalum pentoxide, a product is formed which contains combined Mg. Ta reacts with HCl to form $TaCl_5$.

(971) Aluminum Foil and Powder. *Metal Ind. (N. Y.), 28,* 159-61 (1930). Notes on their manufacture are given.

(972) Zinc Dust. D. Brzeziner, *Metallbörse, 20,* 790-1 (1930). A brief review of manufacture, properties and uses, and production statistics 1926-1928, is presented.

(973) Tungsten Powder. W. G. Burgers and J. A. M. Van Liempt, *Rec. trav. chim., 50,* 1050-51 (1931). Tungsten powder is produced by electrolytic deposition at 500° C. (930° F.) from molten wolframates of potassium, sodium and lithium.

(974) Extraction of Tantalum and Columbium from Ores. C. G. Fink and L. G. Jenness, *Am. Inst. Mining Met. Engrs. T.P. 379,* 1931, 15 pp. Treatment of tantalites and columbites with hydrofluoric acids produces fluorides for the fusion electrolysis of the metals.

(975) Electrolysis in Fused Phosphates. H. Hartmann, F. Ebert and O. Bretschneider, *Z. anorg. allgem. Chem., 198,* 116-40 (1931). The production of tungsten powder by fusion electrolysis of tungstic salts containing tungstic acid, alkali metals and pyrophosphates is described. In addition to the regular modification, another one, β-tungsten, was obtained when bath temperatures were between 650-700° C. (1200-1290° F.). Above the latter temperature, the β-modification transforms irreversibly into the regular one.

(976) The Causes of Formation of Zinc Dust. R. Brosius, *Rev. universelle mines, 8,* 317-24 (1932). Forming of Zn oxide by the introduction of air into the furnace and the condenser. During the last hours of the reduction the temperature is so high that Zn oxide volatilizes. The velocity of the gases and the low temperature of the condenser influence the formation of dust.

(977) Research on Beryllium. H. A. Sloman, *J. Inst. Metals, 44,* 365-91 (1932). Distillation of molten beryllium and solidification in form of powder is described.

(978) Handbook of Inorganic Chemistry. L. Gmelin, *Gmelin's Handbuch der anorganischen Chemie.* Verlag Chemie, Berlin, 1933, System No. 54. Manufacture of tungsten powder from pure tungstic acid.

(979) Aluminum Powders and Their Fabrication. H. Rabaté, *Peinteures, pigments, vernis, 10,* No. 4, 64-67 (1933). Corrosion of Al compounds and preparation of the surface of Al particles during manufacture are discussed.

(980) Nickel Extraction by the Mond Process. *Ind. Chemist, 10,* 253-64 (1934). A description is given of the work carried out at the Clydack Refinery of the Mond Nickel Co., Ltd.

(981) Production of Pure Chromium. P. P. Alexander, *Metals & Alloys, 5,* No. 2, 37-38 (1934). Cr_2O_3 prepared from distilled CrO_3 was reduced to metallic Cr having a purity of the order of 99.95% by means of reaction with the hydrides of both Ti and Ca.

(982) Preparation of Pure Vanadium. T. Döring and J. Geiler, *Z. anorg. allgem. Chem., 221,* 56-62 (1934). Prepared in powder form by reduction of V trichloride in H at 900° C. (1650° F.).

(983) J. L. Gregg, *The Alloys of Iron and Tungsten.* McGraw-Hill, 1934, 510 pp. On pp. 15 ff. it is stated that reduction temperature, moisture content of the hydrogen and tap weight of the oxide determine the particle size of the tungsten powder; other information on tungsten powder is contained on pp. 139 ff.

(984) Separation of Tantalum from Aqueous Solutions. W. Isgarischew and A. F. Prede, *Z. Elektrochem., 40,* No. 6, 295-97 (1934). Columbium is electrolytically separated from tantalum in aqueous solutions by the addition of citric acid.

(985) Manufacture of Powdered Aluminum. A. Dumas, *Rev. aluminium, 12,* 2739-2744 (1935). A description of the "Hametag" process in three operations: roughing, crushing, polishing.

(986) Mercury in Powder Form. A. Galatzky, *Bull. soc. chim. France, 5,* No. 2, 1801-07 (1935). Preparation and properties of the powder are discussed. Mercury powder is a mixture of metallic mercury and mercurous oxide, the latter preventing the metal droplets from congealing completely and forming a continuous liquid phase.

(987) Apparatus for the Production of Aluminum Granules in Larger Quantities. G. E. Lenk, *Metall u. Erz, 32,* No. 1, 5-6 (1935). Design, construction and operation of plant is published.

(988) New Method of Preparing Pure Vanadium. A. Morette, *Compt. rend., 200,* 1110-1111 (1935). V tetrachloride is passed with current of pure H over pure Mg filings in a magnesia boat; the temperature is increased progressively to 700° C. (1290° F.) and a grey powder of 99.3% V is obtained.

(989) Aluminum Powders and Their Fabrication. H. Rabaté, *Peinteures, pigments, vernis, 12,* No. 8, 163-165, 185-187 (1935). Admixing of fat is necessary during the stamping, to hinder a welding of the particles by the heat of friction during the working of the powder.

(990) Aluminum Powders: Their Manufacture. H. Rabaté, *Recherches et inventions, 16,* 214-18 (1935). A description of present-day practices is given.

(991) Tungsten. W. O. Vanderburg, *U. S. Bureau of Mines Inf. Circ.,* No. 6821, 1935, 30 pp. Includes information on the manufacture of W powder.

(992) Manufacture of Aluminum Powder. Yu. A. Kljatchko, *J. Applied Chem. (U. S. S. R.), 9,* 2134-2137 (1936). The process of the production of Al powder shows the influence of different kinds of lubrication; a composition of most favorable properties is proposed.

(993) Preparation of "Raney's Nickel". R. Paul and G. Hilly, *Bull. soc. chim. France, 3,* No. 12, 2330 (1936). The compounds $NiAl_2$ and $NiAl_3$ are prepared by dropping metal cubes into molten Al and heating to 1200°C. (2190°F.); in the case of $NiAl_2$, the reaction occurs with incandescence, and in the case of $NiAl_3$, quietly. The compounds are powdered and digested with 25% sodium hydroxide to produce reactive Ni powder.

(994) Metallic Powders and Dust (in Russian). V. P. Pavlov, *Redkie Metal., 11,* 57-60 (1936). Aluminum powder manufacture is reviewed.

(995) Aluminum Powder, Its Manufacture and Uses (in Russian). I. I. Tolmachev, *Legkie Metal., 3,* 50-4 (1936). A review of the subject is presented.

(996) Technology of Aluminum and Its Light Alloys. A. v. Zeerleder, *Technologie des Aluminiums und seiner Leichtlegierungen,* Gustav Fork, New York, 1936. Aluminum powder fabrication is described on pp. 222-224.

(997) Electrochemical Researches on Titanium. M. Haissinsky and H. Emmanuel-Zavizziano, *J. chim. phys., 34,* No. 11, 641-648 (1937). Extensive investigation into electrolytic production of metallic titanium from aqueous solutions. Solutions studied: titanium sulfate; ammonium fluotitanate; titanium salicylate; tartrate. Experimental procedure and results obtained with the different solutions are described.

(988) New Method of Preparing Pure Vanadium. A. Morette, *Compt. rend., 200,* 1110-1111 (1935). V-tetrachloride is passed with current of pure H over pure Mg filings in a magnesia boat; the temperature is increased progressively to 700° C. (1290° F.) and a grey powder of 99.3% V is obtained.

(999) The Modern Method of Manufacturing Aluminum Powder. H. Meyersberg, *Aluminum and Non-Ferrous Rev., 3,* 299-302, 325-27, 397-99 (1937). A review of the different methods of producing metal powders and flakes. A new process employs nitrogen for protection; the gas containing 1-3% oxygen produces oxide films of controlled thickness. Flaking is done in a drum containing steel balls which drop on the powder during rotation.

(1000) The Evolution of the Nickel Industry. R. L. Mond, *Chem. et ind., 38,* No. 5, 835-839 (1937). Discussion of scientific method with the Mond nickel process as an illustration. The use made of the process and the increased production of Ni, *e.g.*, as powder, is described.

(1001) Preparation of Iron Powder. P. M. Zarelevitch, *Trans. Inst. Pure Chem. Reagents (U. S. S. R.),* No. 15, 51-57 (1937). By reduction Fe_2O_3 and $Fe(OH)_3$ with H in electric furnace; best results obtained by heating to 700° C. (1290° F.) for 40 min. with 4.5 parts of H in excess of theory. Purification of H by removal of O by passing through alkaline solution of pyrogallol and drying with H_2SO_4.

(1002) The Hydride Process. IV. P. P. Alexander, *Metal & Alloys, 9,* No. 10, 270-74 (1938). Reference is made to mineral supplies of uranium; laboratory methods of preparation; hydride process of production of uranium powder and acid resisting uranium alloys.

(1003) Magnesium in Powder Metallurgy. E. J. Groom, *Light Metals, 1,* 33-4 (1938); *Metals & Alloys, Met. Abstracts, 9,* 509 (1938). Production of Mg powder, type of powder, surface conditions and inter-particle attraction are discussed.

(1004) The Modern Method of Manufacturing Aluminum Powder. H. Meyersberg, *Aluminium & Non-Ferrous Rev., 4,* 5-8 (1938). A review of the different methods of producing metal powders and flakes.

(1005) I. Tolmatshev, *Manufacture of Granulated and Powdered Aluminum and Thermite,* Moscow & Leningrad, Gonti, 1938, 80 pp. Review of different mechanical processes is presented.

(1006) Technology of Aluminum and Its Light Alloys. A. von Zeerleder, *Technologie des Aluminiums und seiner Leichtmetalle,* Akademische Verlagsges., Leipzig, 1938. Aluminum powder production is described on pp. 337-340.

(1007) Iron Powder from Sponge Iron. E. P. Barrett, *Steel, 105,* No. 18, 48-52 (1939). Extensive work done by Bureau of Mines is surveyed. Fe powder is obtained by reduction by means of a two-diameter direct-fired rotary kiln. Solid carbon is used as reducing medium.

(1008) Electrodeposition of Tungsten Powder. V. Jolkin and A. Glazunov, *Atti X Congr. Intern. Chim., 4,* 353-9 (1939). Is accomplished on copper above 80° C. (175° F.); redissolving of the Cu after ½ hour is possible. Electrolysis from alkaline medium is described.

(1009) Production of Aluminum Powder. H. W. Jones, *Light Metals, 2,* No. 3, 94 (1939). Al powder is obtained by stamping Al sheet to produce Al paste pigments, to enable production of extremely thin fine flakes economically.

(1010) Decarburization of Granulated Pig Iron; the "R.K.-Process". B. Kalling and I. Rennerfelt, *Jernkontorets Ann., 123,* 115-54 (1939); *Iron & Coal Trades Rev., 89,* 359-360 (1939). Process results in spongy iron powder.

(1011) Chemical Preparation of Molybdenum. R. Lautie, *Bull. soc. chim. France, 6,* No. 7, 1236-8 (1939). By reducing Mo dioxide with calcium; the reaction product is extracted with water and then with very diluted hydrochloric acid. Mo powder of 99.6% purity is obtained.

(1012) Properties and Metallurgical Uses of Calcium. C. L. Mantell and C. Hardy, *Metals & Alloys, 10,* No. 2, 52-6 (1939). Production of powdered calcium by fusion electrolysis is included in discussion.

(1013) Production of Tungsten Metal Powder. J. Murphy, *Western Mach. & Steel World, 30,* 318-19 (1939). A concentrate of wolframite containing 60-77% WO_3 is ground very fine and digested in acid to give 99.5% WO_3 which is dried and calcined and reduced to tungsten.

(1014) Electrolytic Production of Zirconium Powder. V. A. Plotnikow and E. J. Kiritschenko, *Zapiski Inst. Chem. Acad. Sci. Ukraine S. S. R., 6,* No. 1, 1-17 (1939). The electrolytic deposition of the metal from fused salts is described.

(1015) Heat Treatment of Tungsten and Molybdenum. W. D. Relyea, *Heat Treatment and Forging, 25,* No. 2, 92-5 (1939). A rotary heating machine for roasting ammonium molybdate to produce Mo oxide and a gas-fired reduction furnace to produce pure Mo in gray powdered form are discussed.

(1016) Preparation of High-Purity Iron. J. G. Thompson and H. C. Cleaves, *J. Research Natl. Bur. Standards, 23,* Rept. 1226, 163-77 (1939). Reduction of pure oxide to sponge and heating in hydrogen and vacuum.

(1017) The Working Up of Zinc Dust from the Faber-DuFaure Furnace. A. L. Tseft, *Tsvetnye Metal., No. 14,* 97-101 (1939). Treatment of dust is carried out in Harris apparatus in which caustic soda and sodium chloride are loaded, and when the salts are melted, Zn dust is added to saturation point. Au, Ag, Cu and Sb dissolve in circulating lead.

(1018) Production of Zinc Dust. B. V. Vakhmistrov, *Tsvetnye Metal., 14,* No. 4, 132-134 (1939); *Chem. Abstr., 34,* 5390 (1939). Zn is distilled at 590° C. (1100° F.); vapors are cooled at 120° C. (250° F.) and dust is sieved.

(1019) Production of Iron of High Purity. I. Yensen, *Ind. Heating, 6,* 600-1, 628 (1939). Preparation of electrolytic Fe powder, heated in vacuum and hydrogen for subsequent purification.

(1020) Researches of Mellon Institute 1939-40. Electrolytic Iron and Powdered Metals. *Ind. Eng. Chem., News Ed., 18,* 291 (1940). A brief summary of present and future status of electrolytic iron powder development conducted under a fellowship from Plastic Metals, Inc.

(1021) Iron Powder. *Am. Machinist, 84,* 852 (1940). Metal Refining Co., a Division of the Glidden Co. in Hammond, Ind., has begun production of iron powder equivalent to Swedish iron powder.

(1022) Electrolytic Iron and Powdered Metals. *Ind. Eng. Chem., News Ed., 18,* No. 7, 291 (1940). Researches of Mellon Institute 1939-40 on development of electrolytic iron powder for powder metallurgy parts.

(1023) Iron Powder. *Product Eng., 11,* 459 (1940). Iron powder equivalent to Swedish iron powder now available as domestic material (product of Metals Refining Co., Hammond, Ind.).

(1024) Iron Powder from Scale. R. Koprizhiva, *Novosti Tekhniki, 5,* No. 13-14, 25 (1940); *Chem. Abstr., 35,* 2455 (1940). Scale is ground to 200 mesh and reduced in H_2 at 650-800° C. (1200-1470° F.) for 1-2 hrs. Product containing 60-75% Fe is then oxidized by heating to 600-700° C. (1110-1290° F.) in air; the oxidized powder is subjected to a second reduction with H_2 at 800° C. (1470° F.) for 2-3 hrs. Final product contains 92-99% metallic Fe.

(1025) Preparation of Titanium Powder. W. Kroll, *Trans. Electrochem. Soc., 78,* 35-47 (1940). $TiCl_4$ is reduced with Mg in a Mo-lined crucible, in presence of argon at 1000° C. (1830° F.); this is followed by separating the Ti from the Mg salt. Older methods include reduction of $TiCl_4$ with Na in a steel bomb and reduction of TiO_2.

(1026) The Preparation of Zinc Powder by Electrolysis of Zincate Solution. G. Haenseland M. Passer, *Wiss. Veroeffentl. Siemens-Werke, Werkstoff Sonderheft,* 124-137 (1940); *Chem. Zentr.* (II) *112,* 1252 (1941). Experiments on the electrolytic preparation of Zn powder and on the influence of variation of the conditions of electrolysis on the form of the deposit are described.

(1027) Iron Powder Made by General Aniline Works. *Barron's, 21,* No. 37, 26 (1941). Carbonyl iron powder production is described.

(1028) Carbonyl Iron Powder. *Electronics, 14,* No. 4, 116 (1941). Advance Solvents & Chemical Corp. will be distributors for various types of carbonyl iron.

(1029) Production of Aluminum Powder. *Light Metals, 4,* No. 47, 242 (1941). An account is given of a process by D. M. Boothman, U. S. Pats. 2,011,850 and 2,011,851 for the production of Al powder by rolling followed by stamping; and another patent by S. Tour, U. S. 2,199,191, in which drops of molten metal fall between rolls.

(1030) Iron Powder. A. H. Allen, *Steel, 109,* No. 14, 58-9, 90-91 (1941). Survey of many important production methods, especially chemical reduction processes.

(1031) Domestic Iron Powder. G. J. Comstock, *Steel, 108,* No. 18, 88 (1941). Iron powder produced from liquid iron pentacarbonyls is described.

(1032) Powdered Iron, a By-product of Bauxite Purification. F. Giolitti, *Metal Progress, 39,* No. 3, 333-334 (1941). Very pure sponge iron is obtainable by reduction of high-purity magnetite; previously only obtained by transformation of other oxides extracted from the ores.

(1033) Iron Powder from Mill Scale. R. Koprizhiva, *Khim. Referat. Zhur., 4,* No. 4, 90 (1941). cf: *Novosti Tekhinki, 5,* No. 13-14, 25 (1940).

(1034) Sponge Iron and War Production. *Iron Coal Trade Rev., 145,* No. 3889, 765-766 (1942). Reference is made to a report by the U. S. Advisory Committee on Metals and Minerals.

(1035) Progress in Research and Control. *Light Metals, 5,* No. 51, 128-33 (1942). The production of Magnesium powder is described.

(1036) A New Process for Aluminum Powder. *Light Metals, 5,* No. 53, 197-201 (1942). The Flinger-wheel plant and the process for the production of Al powder is described. The method was already reported 40 years ago. It appears to have been put to successful commercial use for the first time in the U. S. S. R.

(1037) New Process for Aluminum powder. *Metals & Alloys, 16,* No. 2, 306 (1942); *Light Metals, 5,* 197-201 (1942). Process of atomizing aluminum powder utilizes the rotating disk liquid metal disintegrator. Details of construction of the flying wheel, holding pot and openings are given together with the characteristics of the resulting powder.

(1038) Electrolytic Iron Powder. *Steel, 110,* No. 14,112(1942). Process for its production was developed at Ford Motor Co.

(1039) Production of Iron Powder. R. A. Boyer, *Steel, 110,* No. 14, 88 (1942). From low-grade ores, which are leached with HCl and subjected to electrolysis.

(1040) Comminuted Forms of Aluminum. J. D. Edwards, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 9, pp. 124-131. Aluminum powder produced by beating, stamping, granulation, graining and atomizing; characteristics of the powder products are discussed.

(1041) Gold Powder Production. R. Leblanc, *Can. Mining J., 63,* 213, 297, 371 (1942). Precipitation of gold from cyanide solution by zinc dust is described.

(1042) Powder Metallurgy of Tin. H. C. Watkins, *Metals & Alloys, 15,* No. 5, 751-757 (1942); *Metal Ind. (London), 61,* 146-49 (1942). Manufacture of Sn and alloy powders is covered.

(1043) Production of Low Sulphur Sponge Iron. R. C. Buehl and E. P. Shoub, *Mining and Met., 24,* No. 444, 550 (1943). A practical method of production of sponge Fe of low S content in rotary kilns from Fe ore and commercially available solid reducing agents has been developed by Bureau of Mines Sponge Iron Project at the Plant of Plastic Metals, Inc.

(1044) Production of Manganese by Electrolysis. P. L. Dubois-Valette, *Compt. rend., 216,* No. 19, 636-38 (1943). The production of the metal in powder form by electrolysis and subsequent mechanical pulverization is described.

(1045) Pure Tungsten Direct from Ore. C. G. Fink and C. Ç. Ma, *Trans. Electrochem. Soc., 84,* 33-63 (1943). Electrolytic tungsten powder is produced from borax and phosphate melts. Experimental results showed that a WO_3 recovery can be obtained by fusing tungsten ores with alkali borate or phosphate. An alkali carbonate bath has disadvantages, *e.g.*, rapid graphite anode consumption.

(1046) Iron Powder. C. V. Firth, *Information Circ. No. 3, Univ. Minnesota Mines Expt. Sta.,* Minneapolis, Minn., May 1943, 9 pp. Production of iron powder at the Mines Experiment Station based on concentration and reduction of Mesabi Range carbonate slate, a highly siliceous ore; discussion of pilot plant operation.

(1047) Iron Powder. C. Hardy, *Metal Progress, 43,* No. 1, 62-64, 126 (1943). General article on production of different kinds of Fe powder and their applications.

(1048) Magnesium. W. Martin, *Mém. soc. ing. civils France, 96,* 333-43 (1943). Production of powder by thermal process, chemical reactions, properties, and applications are discussed.

(1049) Sponge Iron. M. Mathy and P. Mathy, *Mém. Assoc. Ing. École Liège,* No. 111, 107-115 (1943). Various processes for production of sponge iron are reviewed, and details are given for the reduction with water gas. Sponge Fe is used in powder metallurgy and for the deposition of Cu or Pb.

(1050) Production of Iron Powder in North America and England. H. Wiemer, *Stahl u. Eisen, 63,* 30-31 (1943). A review of the different production methods, predominant in the respective countries.

(1051) Preparation of Zirconium. H. v. Zeppelin, *Metall u. Erz, 40,* 252-4 (1943). By heating a mixture of $ZrCl_4$, KCl, Mg in a Fe crucible, to obtain metallic Zr. By washing it with H_2O and HCl a finely powdered Zr is produced.

(1052) Making Magnesium. *Elect. Review (London), 134,* No. 3452, 77-81 (1944). Processes involved in production of Mg as carried out in specially designed plant, with particular reference to electrically heated furnace retorts in which distillation is effected on thermo-reduction principle; raw materials are powdered Al which is prepared in special section of factory plant, and Mg oxide which is produced elsewhere from sea water by precipitation.

(1053) Aluminum Powders. *Iron Age, 153,* No. 22, 55-58, 135-137 (1944). A. Galbraith's discussion of the subject at First Annual Spring Meeting of Metal Powder Assoc., New York, May 5, 1944. Atomized, granular and flake Al production. Fire and explosion hazards and post-war uses of Al powder.

(1054) Preparation of Aluminum Powder. A. G. Arend, *Paint Technol., 9,* 79-80 (1944). Practical details of methods of manufacture are given.

(1055) Copper in Powder Metallurgy. J. J. Cordiano, *Trans. Electrochem. Soc., 85,* 97-106 (1944). Three methods of making copper powder are described, *i.e.,* by electrolysis, by reduction of oxide, and by atomization. Results have effect on particle size and shape of copper powders.

(1056) Electrolytic Iron Powders. B. T. DuPont, *Iron Age, 153,* No. 22, 55 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Description of the manufacture of pure iron powders is given.

(1057) Aluminum Powders. A. Galbraith, *Iron Age, 153,* No. 22, 58, 135 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. The production and uses of aluminum powder are reviewed.

(1058) British Electrolytic Copper Powder. H. W. Greenwood, *Metallurgia, 30,* No. 175, 181-184 (1944). Informatively discussed from technical and economic angle; grades available for special applications in powder metallurgy.

(1059) New Materials. F. K. Harris, *Rev. Sci. Instruments, 15,* No. 7, 198 (1944). Iron powders made by General Aniline Works are described. Carbonyl iron powders are produced by thermal decomposition of iron pentacarbonyl.

(1060) Ultrafine Iron Powder. E. J. Kohlmeyer and H. Spandau, *Arch. Eisenhüttenwesen, 18,* 1-6 (1944/45). Obtained by vaporization of iron by means of an air or oxygen blast on carbon-rich molten metal, or by adaptation to iron of the method of vaporizing in the electric arc ("Solutierverfahren").

(1061) Magnesium Powder Fabrication. W. W. Moss, Jr., *Light Metal Age, 2,* No. 1, 10-13, No. 2, 17-19, 24, 30, 38 (1944). Details of "Hammer-Mill" process and machinery of fabricating Mg powder.

(1062) Electrodeposition of Copper Powder. W. H. Osborn and S. B. Tuwiner, *Trans. Electrochem. Soc., 85,* 107-117 (1944). Powder production is made a part of the process of electrolytic refining of Cu.

(1063) Sponge Iron. C. F. Ramseyer, *Iron & Steel Engr., 21,* 35-44, 72 (1944). Various processes for sponge iron production are reviewed. Details of procedure used in plant at Warren, O., of Republic Steel Corp. are given.

(1064) Electrolytic Copper Powder. G. B. Smith, *Iron Age, 153,* No. 22, 55-56 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944. Three different procedures in the electrolysis of Cu are described.

(1065) Aluminum Powder. *Metal Ind. (London), 66,* 22, (1945). Aluminum powder produced by the Hardy Metallurgical Co., New York, is discussed.

(1066) Sponge Iron. R. S. Dean, *U. S. Bur. Mines Rept. Invest. 3790,* (1945). Finely divided Fe oxide can be metallized by gaseous reduction, by suspending the ore in pure gas. Reduction with subsequent purification is possible.

(1067) Molybdenum Production and Use. W. H. Dennis, *Mine & Quarry Eng., 10,* 119-120 (1945). Molybdenum powder production steps are reviewed.

(1068) Copper Powder by Electrodeposition. A. W. Hothersall and G. E. Gardam, *J. Electrodepositors' Tech. Soc., 20,* 61-68 (1945); Abstr. in *Metal Progress, 48,* No. 5, 1134 (1945). Recommended conditions for production of Cu powder by electrodeposition are published.

(1069) Copper Powder – Commercial Preparation by Electrodeposition. A. W. Hothersall and G. E. Gardam, *Metal Ind. (London), 66,* No. 15, 234-6 (1945). Results of laboratory investigation carried out for British Non-Ferrous Metals Research Assoc., object of which was to determine most suitable conditions for production of copper powder on pilot plant scale.

(1070) Production of Iron Powder from very Pure Iron Ore Concentrates. W. Luyken and H. Kirchberg, Kaiser Wilhelm Institut für Eisenforschung. *H. E. C. Rept. No. 13713* (1945). Swedish magnetic concentrates are reduced first with H in rotary furnace with intermediate magnetic separation, and then treated on trays in H-swept retort.

(1071) Iron Powder. *J. Chem. Ed., 23,* No. 10, 512 (1946). A new method of preparing Fe powder directly from pulverized iron ore by reducing the ore at low temperatures is described in a patent application filed in Germany by the Kaiser Wilhelm Institut in Düsseldorf.

(1072) New Iron Powder Plant for U. S. A. *Internatl. Ind., 27,* 499 (1946). New Plant to be built by the Tacoma Powdered Metals Co. for electrolytic iron powder production is announced.

(1073) New Minnesota Plant to Make Iron Powder from Slate Wastes. *Wall Street J., 128,* No. 42, 6 (1946). A laboratory process, in which iron carbonate slate is dissolved in acid and the product reduced to iron powder with a purity of 99%, is to be used in a new million-dollar plant being built in the Mesabi region of Northern Minn.

(1074) Aluminum Powder Production. G. W. Birdsall, *Steel, 118,* No. 2, 82-85, 98, 100, 103 (1946). Novel methods at Reynolds Metals using three different processes. Al powders find increasingly important applications in coatings, chemical processes, pyrotechnics, powder metallurgy, etc.

(1075) I. G. Farben Industrie - Oppau and Norddeut. Affinerie - Hamburg. T. S. Charleson, T. H. Davey and L. B. Pfeil, B. I. O. S. Final Rept. No. 263 (1946). Nickel and iron powder plant. Treatment of nickel-copper ores and residues.

(1076) Report on Nickel- and Iron-Powder Plants of I. G. Farbenindustrie. T. S. Charleson, U. S. Dept. Comm. PB. 18951/1945, 24 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 23, 1406 (1946). Efforts to produce iron powder of best magnetic properties. Volatilizers for Fe-carbonyl and Ni-carbonyl production. (See also B. I. O. S. Final Rept. 263.).

(1077) I. G. Farbenindustrie, Ludwigshafen-Oppau. T. P. Colclough, C. I. O. S. Rept. No. XXIV-12 (1946). This report on carbonyl iron manufacture at the I. G. carbonyl nickel plant was later incorporated in B. I. O. S. Final Rept. No. 263. See also *Metal Progress, 50,* No. 2, 332, 342 (1946).

(1078) Nickel Production. T. P. Colclough, *Metal Ind. (London), 68,* No. 21,416 (1946). Brief description of carbonyl process for production of Ni powder used by I. G. Farbenindustrie, Oppau Works in Ludwigshafen, Germany, From report of T. P. Colclough, C. I. O. S. Rept. No. XXIV - 12.

(1079) German Chromium Powder. T. P. Colclough, U. S. Dept. Comm. PB 350, 1946; *Powd. Met. Bull., 1,* No. 2, 25 (1946). Report based on C. I. O. S. Rept. No. XXIV-12 on the production of high-purity chromium at the Oppau Works of I. G. Farbenindustrie.

(1080) Production of Iron Powder in Tunnel Kiln. Deutsche Pulvermetallurgische Gesellschaft. U. S. Dept. Comm. PB. 22344/1945, 6 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 20, 1182 (1946). Report gives brief description of history of production of iron powder, starting with the Hametag process and following with the description of more efficient and economical methods used in Germany.

(1081) Dephosphorization of Iron Alloys by Alkali Earth Metals and Manufacture of Iron Powder. W. A. Fischer and J. Heyes, U. S. Dept. Comm. PB. 14711, 1946; *Bibl. Scient. & Ind. Rept., 1,* No. 24, 1491 (1946). Describes a process in which P-containing Fe is heated with magnesia at 500-1100° C. (930-2010° F.); the resulting magnesia phosphide is boiled out with water and 90-95% P are removed. After separation of the Mg oxide, the Fe produced is suitable for production of powder for sintering.

(1082) Preparation of Titanium Powder. K. R. Hanna and H. W. Worner, *J. Council Sci. Ind. Research, 19,* 449-54 (1946). The method selected was a modification of one method by W. Kroll, *Trans. Electrochem. Soc., 78,* 35 (1940), concerning the reduction of $TiCl_4$ with Mg. The product contains 98% Ti.

(1083) Nickel in War Time Germany. D. D. Howart, *Chem. Age (London), 55,* No. 1416, 191 (1946). Production of Ni powders at plant of I. G. Farbenindustrie at Oppau is described.

(1084) The Manufacture of Iron Powder in Tunnel Furnace. F. Kaysser and F. Kassner, Metallgesellschaft A. G., F. D. Rept. No. 1765/46 (1946). Iron powder and reducing agent were put into ceramic containers and stacked on cars which were passed through the tunnel furnace. Surprisingly low figures were given for the cost. Process developed and in operation in 1940-44.

(1085) Miscellaneous Chemicals. I. G. Farbenindustrie, A. G., Ludwigshafen and Oppau. J. G. Kern, R. L. Murray and R. W. Sudhoff. C.I.O.S. Rept. No. XXVII-85 (1946). Includes a brief description of the iron and nickel carbonyl plant.

(1086) Ferro-Alloy Manufacture and Uses. A. B. Kinzel, F. I. A. T. Rept. No. 485, 1946, 14 pp.; *Met. Powd. Rept., 1,* No. 1, 5 (1946). It is noted that at Elektro-Metallurgie A. G., Nuremberg, manganese powder was produced by ball milling the metal in CO_2.

(1087) Electrolytic method of Preparation of Nickel Powder. A. J. Levin, *J. Applied Chem. (U. S. S. R.), 19,* No. 8, 779-787 (1946). Cathodic precipitation of Ni in powdered form followed by annealing in H_2 at 700° C. (1290° F.) is best method for production of highly active powdered Ni.

(1088) Cathodic Preparation of Finely Dispersed Nickel. M. Loshkarev, A. Kryukova and O. Gornostaleva, *J. Applied Chem. (U.S.S.R.), 19,* No. 8, 46-50 (1946). Optimum conditions for preparation of powdered Ni are obtained from pure $NiSO_4$ solution and from electrolytes containing Cu-Fe products possessing high activity.

(1089) Iron Powder from Purest Ore Concentrates. W. Luyken and H. Kirchberg, U. S. Dept. Comm. PB. 6789 (1946); *Bibl. Scient. & Ind. Rept., 1,* No. 16, 859 (1946); *Powd. Met. Bull., 2,* No. 2, 38 (1947). Direct production of Fe powder of predetermined particle size. Distribution by reduction of pure Swedish ore concentrates.

(1090) Electrolytic Separation of Zr as Powder. V. A. Plotnikov and E. B. Gitma, *J. Applied Chem. (U. S. S. R.), 19,* No. 8, 826 (1946). New method of electrolytically separating Zr as a coarse-grained powder for use in Zr alloys is described.

(1091) Report on First Meeting for Production of Iron Powders. Reichsminister für Rüstung und Kriegsproduktion, U. S. Dept. Comm. PB. 17391/1944, 8 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 4, 278 (1946). Lectures and discussion on: mechanically produced powders; sponge-iron powders; centrifugal produced powders; atomized powders; the Berghaus chlorination process; the Walther process; the principles of the raw iron-cinder layer process.

(1092) Beryllium Industries of Germany and Italy. H. A. Sloman and C. B. Sawyer, F. I. A. T. Rept. No. 522 (1946). Manufacture of Be powder and some details are given.

(1093) Preparation of Beryllium Powder. J. M. Tien, *Trans. Electrochem. Soc., 89,* 223-31 (1946). Experiments on preparation of Be metal powder have been carried out *(1)* by electrodeposition of Be from non-aqueous solvents; *(2)* by electrolysis of fused salts below 120° C. (245° F.) and by *(3)* reduction of anhydrous Be chloride under reduced pressure by metallic sodium in vapor state. The last process gave satisfactory results.

(1094) Production of Sponge Iron with Producer Gas. D. R. Torgeson, T. E. Evans and R. G. Knickerbocker, *U. S. Bur. Mines Rept. Invest. No. 3994,* 1946, 42 pp. Sponge iron can be produced in multiple-hearth furnace by reduction with a low-quality producer gas.

(1095) Production of Electrolytic Iron Powder. H. V. Trask, *Metal Progress, 50,* No. 2, 279-282 (1946). Pilot plant installation and production of Fe powder at Bu-El Metals Co. of Ohio, with a capacity to produce approx. 400 lbs. of powder per day, is reported.

(1096) Review of Work of Kaiser Wilhelm Institut on Powder Metallurgy of Iron. H. Wiemer, U. S. Dept. Comm. PB. 14760, 1946, 11 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 19, 1108 (1946). Preparation of iron powders is described.

(1097) Powdered Iron Produced by Electrolysis. *Chem. Eng., 54,* 188 (1947). Process uses: insoluble anodes, and steel borings and turnings and hydrochloric acid and hydrogen for ferrous chloride solution as electrolyte.

(1098) Electrolytic Iron Powder. *Intern. Ind., 28,* 349 (1947). Large scale production, capable of yielding 10 to 12 tons of powder per day, is reported from the Pacific Coast.

(1099) A New Swedish Iron Powder. *Iron Age, 159,* No. 21, 59-60 (1947). The Swedish sponge iron powder produced by Höganäs is said to be superior to any iron powder previously produced.

(1100) Silver Powder. *Iron Age, 160,* No. 6, 88 (1947). Silver powder, chemically precipitated by Allymet Mfg. Co., has 99.97% purity.

(1101) Increased Production of Non-Ferrous Metal Powder. *Materials & Methods, 25,* No. 1, 7 (1947). Carteret, N. J., plant of U. S. Metals Refining Co. visited. Output and production capacity for electrolytic copper powder is discussed.

(1102) Electrolytic Copper Powder. *Metal Ind. (N.Y.), 71,* No. 11, 226 (1947). Production methods employed at plant of Norddeutsche Affinerie, Hamburg, operations and facilities are described.

(1103) Carbonyl Iron Powder. *Product Eng., 12,* No. 7, 385 (1947). Carbonyl iron powder which differs from other iron powders in that it has an extremely small spherical size, ranging from 1- 5 microns, is now produced in U. S.

(1104) Manufacture and Use of Iron Powder in Germany. W. G. Cass, *Ind. Diamond Rev., 7,* No. 78, 152-3 (1947). A review of B. I. O. S. Final Report No. 860 "Iron Powder, Note on German Production. Methods at Düsseldorfer Eisenhüttengesellschaft, and Deutsche Eisenwerke" by J. C. Richards.

(1105) Manufacture and Uses of Iron Powder. F. Eisenkolb, *Arch. Metallkunde, 1,* No. 7/8, 327-334 (1947). Describes different German processes (Hametag, D. P. G., RZ) and quality of powders. Hametag process is still most widely used.

(1106) Production of Iron Powder by Electrodeposition. G. E. Gardam, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38 *(London),* 1947, pp. 3-7; *Met. Powd. Rept., 1,* No. 11, 161-162 (1947). Experiments are described on the production of iron powder on a pilot-plant scale by electrolysis of a solution of ferrous ammonium sulfate. The resulting dendritic powder contained about 1% oxygen but had poor compacting properties. After annealing of the powder, the compact showed improved properties.

(1107) Electrolytic Iron Powder Production. W. J. Granberg, *Iron Age, 160,* No. 26, 70-74 (1947). An electrolytic iron powder process, employing insoluble anodes and ferrous chloride, is described. Raw material requirements and operating technique associated with method are outlined on basis of 10 tons per day. New plant operates at Tacoma, Wash.

(1108) Manufacture of Iron Powder in Tunnel Furnace. F. v. Griesewald, F. D. Docum. No. 1765/46, 4 pp.; *Met. Powd. Rept., 1,* No. 5, 67 (1947). The furnace was heated with producer gas in ducts counter-current to the movement of the cars; the heating circuit had to be operated at a slight positive pressure. Metallgesellschaft A. G. quoted in reporting that sintered compacts had a tensile strength of 10,000 psi.

(1109) The Production of Powdered Iron and Sintered Iron Driving Bands in Germany. W. Ivory, B. I. O. S. Final Rept. No. 1323, 1947, 120 pp.; *Met. Powd. Rept., 2,* No. 1, 4-6 (1947). An outline is given of the size and organization of the German wartime production of iron powder.

(1110) German Sintered Iron Driving Bands. W. Ivory, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, (London), 1947, pp. 203-208; *Metal Powd. Rept., 1,* No. 12, 184 (1947). An outline is given of the size and organization of the German wartime production of iron powder.

(1111) Iron Powders and Sintered Components. C. J. Leadbeater and V. G. Ford, B. I. O. S. Final Rept., No. 1223, 1947, 106 pp.; *Met. Powd. Rept., 2,* No. 1, 3-4 (1947). The report contains a detailed investigation of the various German iron powder manufacturing processes, a description of the techniques. The processes include the Hametag process, the D.P.G. disk process, the "RZ" process, the Linz process, and the Vogt process.

(1112) Production of Iron Powder. H. Ley and Metallgesellschaft A. G., F. D. Rept. No. 5054/47 (1947). Formerly H.E.C. Docum. 12207: utilization of waste pickling liquors for production of iron powder and gas purifying mass. Formerly H.E.C. Docum. 12279: estimated costs of production of iron powder from iron sulfate.

(1113) Production of Iron Powder from Purest Ore. W. Luyken and H. Kirchberg, *Arch. Metallkunde, 1,* No. 7/8, 335-345 (1947). Of several reducing methods tried, most satisfactory is reducing material with hydrogen in rotary furnace with intermediate magnetic separations, and then passing concentrates on trays through hydrogen-swept, heated retort. Sintered compacts are similar to those made from other iron powders.

(1114) Production of Iron Powder from Purest Ore Concentrates. W. Luyken and H. Kirchberg, U. S. Dept. Comm. PB. 6789, 1947, 5 pp.; *Powd. Met. Bull., 2,* No. 2, 38 (1947). A direct production of iron powder of predetermined particle size distribution by reduction of pure Swedish ore concentrates from deposits at Kirunawaara, Luossavaara, is described.

(1115) A New "RZ" Process for Production of Cheap High Quality Iron and Steel Powder. G. Naeser, H. Steffe and H.W. Scholz, Mannesmannwerke Forschungs-Institut. F. D. Rept. No. 883/47 (1947). A correct ratio of C to O must be maintained so that both are removed as CO_2 when the powder is subsequently annealed. Cost of the powder is one quarter of Hametag powder, and one third of D.P.G. powder.

(1116) Iron Powder. J. C. Richards, B. I. O. S. Final Rept. No. 860, 1947, 20 pp.; *Met. Powd. Rept., 1,* No. 7, 103 (1947). Notes on German production methods at Düsseldorfer Eisenhüttengesellschaft and Deutsche Eisenwerke.

(1117) The Raw Iron-Cinder Layer Process. H. W. Scholz, U. S. Dept. Comm. PB. 17380 (1947); *Powd. Met. Bull., 2,* No. 2, 30-34 (1947). The "RZ" process was invented by G. Naeser and H. Steffe, and developed by Mannesmann. The resulting iron powder exhibits good compacting and sintering characteristics, has a low C content and uniformly fine particle size.

(1118) Manufacture of Iron Powder by Atomizing. H. Steffe, F. D. Rept. No. 1099/46, 8 pp.; *Met. Powd. Rept., 1,* No. 5, 68 (1947). Description of three German patent applications by the Mannesmannröhren Werke A. G., all concerned with the manufacture of iron powder by atomization: *(1)* molten cast iron; *(2)* low-silicon cast iron; and *(3)* special additions to the melt.

(1119) The German Zinc Industry. R. L. Stubbs, B. D. Darran and J. J. Lowe, B. I. O. S. Final Rept. No. 1159 (1947). The Eckart Works are reported to have made 1000 tons of atomized zinc per annum. Other German production was negligible. For use of the powder as substitute of plain bearings cf. F. D. Docum. No. 1544/47.

(1120) Recovery of Tungsten. Studiengesellschaft Hartmetall. F. D. Rept. No. 3771/47 (1947). According to this report of 1937, tungsten can be recovered from Carborundum grinding wheel dust by heating with quicklime at 900° C. (1650° F.) to form calcium silicate and calcium tungstate, followed by repeated treatment with conc. HCl and washing, dissolving in conc. NH_3 solution, and repeated washing and treatment with HCl, with final washing and drying.

(1121) Recovery of Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3859/47 (1947). A test on 200 lb. of carbide scrap by treatment with sodium nitrite gave a recovery of 96% W (1941 report).

(1122) Study of Process Variables in the Production of Aluminum Powder by Atomization. J. S. Thompson, *J. Inst. Metals, 74,* Pt. 3, 101-132 (1947). Particular attention to rate at which atomization proceeds; size grading of powder; ease and efficiency of operation. Rate of atomization related to the variables: metal heat, air pressure, temperature.

(1123) Preparation of Titanium Powder for Electron Tubes. *Chem. Eng. Min. Rev., 40,* No. 6, 216 (1948). After experimentation with several methods developed in U. S. and Germany, it was found that a modification of the Kroll method was the most suitable for the conditions in Australia.

(1124) Most Important Processes for Manufacture of Iron Powders. H. Bernstorff, *Arch. Metallkunde, 2,* No. 9, 289-95 (1948). The following subjects are discussed: influence on powder properties; processes and equipment; raw materials; reduction technique; characteristics of Fe powder; compressibility; particle size and shape; surface structure; gas content; properties of compressed compacts.

(1125) Carbonyl Nickel and Iron Powders. S. E. Buckley, L. F. Denaro, F. Dickinson, S. J. Garvin, R. J. Halsey, W. Ivory, C. J. Leadbeater, C. E. Richards, A. E. Wallis, and J. Weaver. B. I. O. S. Final Rept. No. 1575, 1948, 35 pp.; *Met. Powd. Rept., 2,* No. 5, 68 (1948). The report covers the interrogation of L. Schlecht of Oppau Works of I. G. Farbenindustrie A. G. Several I. G. patents were said to cover: *(1)* the production of Ni carbonyl from complex Ni compounds by injecting chlorine; *(2)* the decomposition of carbonyl vapors diluted with carbon monoxide; *(3)* the manufacture of Fe-Al-Ni magnets.

(1126) The Manufacture of Electrolytic Iron Powder. Deutsche Gold- und Silberscheideanstalt. F. D. Rept. No. 1671/48 (1948). A brief account in French, dated 1945, of the working of a small $FeCl_2$ bath.

(1127) Manufacture of Iron Powder from Mill Scale. Deutsche Waffen- u. Munitionsfabriken A. G., F. D. Rept. No. 3531/48 (formerly H.E.C. 5518) (1948). A comprehensive report on laboratory research in 1941, using an electrically heated rotary furnace with hydrogen and city gas atmospheres.

(1128) Sponge Iron and Iron Powder. J. E. Drapeau, *Iron Age, 161,* No. 15, 92-94 (1948). Competition from European sources once again challenges the iron powder industry of U. S. and creates a need for the improvement in powder quality; plans for introduction of new ferrous powders.

(1129) Electrolytic Preparation of Zinc Dust. W. Eckardt, *U. S. Bur. Mines, Inform. Circ. 7466,* 1948, 6 pp. Report of Ludwigshafen research laboratory of I. G. Farbenindustrie A. G. is dated 1939, and describes the preparation of highly reactive zinc dust.

(1130) Production of Lithium. R. B. Ellestadt, *Trans. Can. Inst. Mining Met., No. 438,* 619-22 (1948). Highly purified Li is produced by distillation from a Cu-Al-Li alloy under low pressure. Li alloys of Pb, Zn, Al are produced by electrolysis, but this method is complicated for producing pure Li.

(1131) Reactions of Phosphorus-Containing Alloys with Alkaline Earth Metals and the Manufacture of Iron Powder. W. A. Fischer and J. Heyes, F. D. Rept. No. 691/48 (formerly 13721) (1948). Laboratory experiments up to 1945 on the dephosphorizing of ferromanganese with magnesium, with recovery of phosphoric acid.

(1132) Making Iron Powder in Tunnel Kiln. V. H. Gottschalk, *U. S. Bur. Mines Inform. Circ. No. 7473,* 1948, 16 pp. Supplement of Rept. Nos. 3819, 3822, 3841, 4271 on sponge iron; based on 4 German reports of Metallgesellschaft A. G. solid carbon reduction in a ceramic kiln in Bremen, heated by producer gas; using a protective atmosphere and "locks" at both ends of the kiln.

(1133) The Production of Pure Chromium. H. T. Greenaway, *Council for Scientific and Industrial Research, Division of Aeronautics, Structures and Materials, Note 163,* Jan. 1948, 5 pp.; *Met. Powd. Rept., 2,* No. 11, 173 (1948). Electrolytic chromium was crushed to powder and reduced by heating at 1250° C. (2280° F.) for one hour under a vacuum of about 0.01 mm. Hg.

(1134) Tantalum Powder by Magnesium Reduction. J. P. Isaza, A. J. Shaler and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 175,* 784-90 (1948). Tantalum pentachloride is reduced and the characteristics of the resulting powder are described.

(1135) German Methods for Manufacturing Iron Powder. H. L. Krebs, U. S. Dept. Comm., PB. 78996; *Materials & Methods, 27,* No. 3, 112 (1948). Carbonyl iron powder is made in Germany of better quality than the American powder. The mixing and insulating of the material is different, although the same components are used. Attention is given to low C and low N contents.

(1136) Tungsten and Tantalum. J. A. Lee, *Chem. Eng., 55,* No. 9, 110-12, 152-55 (1948). Production processes such as filtration, crystallization, precipitation and reduction to the metal powder in the plant of Fansteel Metallurgical Corp. are described.

(1137) New Process for Iron Powder Manufacture. G. Naeser, *Met. Powd. Rept., 3,* No. 1, 12 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 179 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 5a. RZ powder, made by atomizing molten cast iron consists of porous hollow spheres or bowl-shaped particles. The inside walls are of porous iron due to decarburizing, upon which a layer of sponge iron is sintered.

(1138) Principles of Mill Scale Process: "R. Z. Method". G. Naeser, H. Steffe, and H.W. Scholz, *Stahl u. Eisen, 68,* No. 19/20, 346-53 (1948). The iron powder manufacturing process is based on the pulverization of molten iron carbon alloys under controlled partial oxidation by blowing with compressed air. Composition of the powder and behavior in pressing and sintering; diagrams and photomicrographs.

(1139) Use of Coal in Zinc Production. W. M. Peirce, *Mining and Met., 29,* 286-287 (1948). About 500,000 tons of ZnO is made by the American process, wherein a layer of coal is ignited on a flat grate with air blast. On top of this hearth layer is charged a mixture of Zn, ore, and coal, and air is introduced into mixture of Zn dust, vapor and combustion products; Zn vapor is burned to pigment-grade ZnO, filtered out of the gas stream.

(1140) Distillation of Zinc from Scrap Brass. F. F. Poland, *Metal Ind. (London), 72,* 331-332 (1948). Molten brass scrap are heated in Wilkins-Poland furnace for distilling Zn, which is conducted to a surface condenser; Cu is transferred to a fire refining unit.

(1141) Present Status of Cobalt Plating. A. Salmony and R. Thews, *Metalloberfläche, 2,* No. 5/6, 114-116 (1948). Review of history of cobalt plating. Particulars on the more recent processes. Requirements to be met to obtain cobalt deposits with a high luster and generally good properties. Mechanism of formation of pores, such as in sponge deposits (suitable for production of powder).

(1142) Manufacture of Iron Powder by D. P. G. Disk Process. H. Timmerbeil, *Met. Powd. Rept., 3,* No. 1, 11 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 180 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 9. The author developed the "SC" process in which Bessemer steel is atomized just as in D. P. G. disk process, but the powder is more highly splattered, and acquires a porous structure.

(1143) Iron Cored D. F. Loops and Manufacture of Iron Dust. K. F. Umplby, F. G. Overbury and G. R. Polgreen, B. I. O. S. Final Rept. No. 1203, 1948, 31 pp.; *Met. Powd. Rept., 1,* No. 9, 133 (1948). Report includes description of production of carbonyl iron powder by I. G. Farbenindustrie A. G.

(1144) Titanium and Zirconium: Metals of Industrial Promise. W. H. Waggaman and E. A. Gee, *Chem. Eng. News, 26,* 377-378 (1948). Pure $TiCl_4$ is poured into reduction furnace containing magnesium at 750° C. (1380° F.) in helium atmosphere. After cooling charge, it consists of Ti, Mg, $MgCl_2$. Bureau of Mines has modified the Kroll method in a number of respects, to render it more suitable for producing large batches of Ti.

(1145) Production of Electrolytic Iron Powder. G. Wranglen, *Jernkontorets Ann., 132,* No. 12, 501-16 (1948). Discussion of production either by direct deposition at the cathode or by grinding of coherent deposit. Bibliography.

(1146) Method of Iron Powder Manufacture. H. Bernstorff, *Metal Treatment, 16,* 93-102 (1949). A review of various German methods of manufacturing iron powder, including grinding, atomization, and electrolytic methods.

(1147) The Modern Methods for Production of Iron Powder. H. Buchholtz, *Stahl u. Eisen, 69,* No. 8, 247-56 (1949). Present processes for production of iron powder, raw materials employed and economy, and status of development of new processes in Germany and abroad.

(1148) Production of Electrolytic Iron Powder. N. T. Kudryavtsev and E. A. Tereshkovitch, *J. Applied Chem. (U. S. S. R.), 22,* 1298-1305 (1949). The authors investigated the various effects, singly and in combination, of ferrous sulfate

concentration, bath temperature, and cathodic current density upon the quality of deposit and current efficiency.

(1149) Preparation and Properties of Electrolytic Iron Powder. L. L. Kuzmin and V. L. Kiseleva, *J. Applied Chem. U. S. S. R., 22,* 311-18 (1949). Describes experiments with sulfate bath in which the effect of pH, temperature, and cathode current density was determined with the object of producing pure iron powder.

(1150) Swedish Iron Powder Imports Defended. N. K. Tholand, *Iron Age, 164,* No. 20, 180-81 (1949). A report on the Höganäs production and the use of powder from Swedish sponge iron in the U. S.

(1151) Some Aspects of Production and Heat-Treatment of Electrolytic Copper Powder. H. J. V. Tyrrell, *J. Inst. Metals, 76,* Pt. 1, 17-42 (1949). Laboratory investigations of production of electrolytic powders in Great Britain described; effect of heat treatment on stability and molding properties of powders produced in plant and laboratory.

(1152) Production of Titanium Powder by U. S. Bureau of Mines. F. S. Wartman, *Metal Progress, 55,* No. 2, 188-90 (1949). $TiCl_4$, according to the Kroll process, is reduced by magnesium in a closed iron chamber between 800-900° C. (1475-1650° F.), and a helium atmosphere is used to avoid oxidation.

(1153) Production of Titanium Powder at Boulder City. F. S. Wartman, *Office Naval Res. Rept. of Symposium on Titanium,* 1949, pp. 20-26. Study of the Kroll process, in which $TiCl_4$ is reduced with Mg in helium atmosphere at 800-900° C. Ti may be recovered from the sponge by $MgCl_2$ or unreacted Mg.

(1154) Preparation and Properties of Ductile Titanium. H. W. Worner, *Metallurgic 40,* 69-76 (1949). Titanium tetrachloride, obtained by chlorination of Australian rutile, was distilled and reduced with magnesium. The yield of Ti from the leached reaction product was 81%, the powder being markedly porous.

B. Alloy Powders (refractory, ferrous, non-ferrous)

(1155) H. Bessemer, *Autobiography.* Engineering, London, 1905, pp. 53-85. Manufacture of bronze powder and designing bronze powder machinery.

(1156) The Manufacture of Bronze Powder, I-V. *Metal Ind. (London), 9,* 165-7, 202-3, 225-7, 309-10, 365-6, 393-4, 449-50, 505-07 (1916). The article covers the uses of the powder for industrial purposes, stamping in general, automatic stamping and shifting, polishing, and a description of aluminum bronze powders.

(1157) The Manufacture of Bronze Powder. O. v. Schlenk, *Metal Ind. (N. Y.), 15,* 77-78, 161-63, 200-203, 298-300 (1917). Historical review. Application of bronze powder. Raw material and presses. Sieves. Polishing. Al Powder.

(1158) Manufacture of Bronze Powder. *Cuivre et laiton, 3,* 107-8 (1930). Descriptive review of various mechanical production methods.

(1159) The Codeposition of Tungsten and Iron from Aqueous Solutions. M. L. Holt, *Trans. Electrochem. Soc., 66,* 453-60 (1934). Experimental results on electrodeposition of tungsten show that in the absence of iron, cessation of deposition occurs. The author believes that a W-Fe alloy is deposited when the solution is impure. The deposit may be incoherent, i. e., a sponge or powder.

(1160) Gold, Silver and Aluminum Bronze Powders. O. A. Both, *Ind. Finishing, 11,* No. 9, 9-11, 46-49 (1935). Making powders and how to test their qualities for various purposes; how to preserve their luster and their durability.

(1161) Production of Powdered Alloys of Low Melting Point. R. W. Rees, *J. Inst. Metals, 57,* 193-95 (1935). A method is described for producing Pb-base alloys in the form of powders. Advantage is taken of the pasty stage through which the alloys pass during solidification.

(1162) Powdering Lead Alloy. R. W. Rees, *Metal Progress, 29,* No. 5, 52-53 (1936). Alloys are used which have wide interval between the liquidus and solidus state; example: 50% Pb, 30% Cd, 20% Sn.

(1163) Making Ferrosilicon by Use of Sintering Process. S. I. Khitrik, *Teoriya i Prakt. Met., 10,* No. 1, 52-4 (1938). Sand and Fe treated in electrical furnace.

(1164) Three Compositions of "Sinterloy" Steel. *Iron Age, 145,* No. 8, 25 (1940). Material available at Chas. Hardy, Inc., New York, in powdered form with 0.15, 0.4 and 0.8% C, is readily processible into pressed forms.

(1165) Steel in Powder Form. *Metals & Alloys, 11,* No. 5, MA 242 (1940); *Machinery, London, 56,* 659 (1940). Commercial notice on "Sinterloy", carbon contents 0.15, 0.4, or 0.8%. Powder obtainable through Chas. Hardy, Inc., New York.

(1166)) Steel Powder for Iron Powder Metallurgy. G. J. Comstock, *Steel, 106,* No. 22, 54-55 (1940). Steel powder can be produced as a by-product of the Kalling-Rennerfelt process.

(1167) Produces Steel from Powdered Metal. *Steel, 107,* No. 26, 66 (1940). Chas. Hardy, Inc., New York, is marketing a steel powder called "Sinterloy," which can be pressed into desired forms and then sintered.

(1168) Ferro Alloys. F. R. Kemmer, *Ind. Australian Min. Stand., 96,* No. 2467, 57-9 (1941). Pilot plant manufacture of ferro tungsten powder is described.

(1169) Stainless Steel Powder. J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chapter 11, pp. 137-144 (1942). Production of powder by the chemical grain boundary disintegration method described; processing of powder and applications also given.

(1170) Codeposition of Cobalt and Copper. C. C. Fink and J. L. Hutton, *Trans. Electrochem. Soc., 85,* 119-122 (1944). Records various attempts made to prepare a 50:50 Co-Cu alloy by electrolytic codeposition; alloy may be deposited in form of a powder.

(1171) New Powders and Flake of Stainless Steel. *Iron Age, 158,* No. 12, 138-139 (1946). A new stainless steel powder is now being produced in commercial quantities by Charles Hardy Inc. Data given for powders compacted at 30, 40, 50 tsi, sintered at 1315° C. (2400° F.) in H.

(1172) Resistant Powder Alloys. *Chem. Age (London), 57,* No. 1482, 736 (1947). The production of stainless steel powder is discussed.

(1173) Stainless Steel Powder. J. D. Dale, *Proc. Third Ann. Meetg. Met. Powd. Assoc.,* New York, May 27, 1947, 4-13. Low carbon 18-8 stainless steel is today a truly pre-alloyed metal whose original grain boundaries are broken down leaving a low carbon grain free of oxide. Studies of blends and their processing into compacts.

(1174) Method for Rapid Production of Pt Alloy Powders. L. Weil, *Compt. rend., 224,* 923-925 (1947); *Met. Powd. Rept., 2,* No. 1, 12 (1947). Production of Pt-Fe, Pt-Co, Pt-Ni powders by reduction of the respective metal platinocyanates in H at 500-600° C. (930-1110° F.) for 2 hrs.

(1175) Thermit Process for Preparation of Ferrotitanium. K. Giesen and W. Dantzenberg, *Stahl u. Eisen, 68,* 159-160 (1948). Ore with 44% TiO_2 is mixed with Al; reduction yields only 62% Ti, but Fe, Mn, Si are fully reduced; addition of lime; maximum yield occurs when the mixture is preheated, or by addition of 80% BaO_2 to the cold mixture.

(1176) High Strength Parts Made From Prealloyed Steel Powders. *Steel, 124,* No. 19, 114 (1949). Vanadium-Alloys Steel Co., Latrobe, Pa., uses Berk & Co. process for producing prealloyed ferrous powders; size of powders determined by rate of flow, temperature and composition of metal; dewatering system; furnace drying; tables show typical size distribution of several powders, and tensile strengths of certain prealloyed steel powders; 100 mesh powder can be cold pressed in lubricated die.

(1177) Prealloyed Steel Powders. G. A. Roberts and A. H. Grobe, *Iron Age, 163,* No. 13, 78-9 (1949). Powders produced by Vanadium-Alloys Steel Co. range from steels and stainless steels of all types to alloys for high temperature applications; description of manufacturing process consisting of disintegrating small molten metal stream with water jets; commercial compositions reported.

C. Compound Powders (carbides, nitrides, borides, silicides and silicates, oxides, hydrides, chlorides)

(1178) A. F. Cronstedt, *Försök till Mineralogie eller Mineral Rikets Upställning*, Stockholm, 1758, pp. 107, 183. Calcium tungstate is mentioned. It is called "tungsten" (heavy stone) because of its remarkably heavy weight.

(1179) On Tungstic Ore Constituents. C. W. Scheele, *Svenska Vet. Akad. Handl., 2,* 89-99 (1781). Calcium tungstate was named "tungsten" (heavy stone) because of its unusually heavy weight.

(1180) Action of Carbon Monoxide on Nickel. L. Mond, C. Langer and F. Quincke, *J. Chem. Soc., 57,* 749-753 (1890); *Chem. News, 62,* 97 (1890). A report is given on the discovery of a new compound formed by the reaction of carbon monoxide and nickel.

(1181) Iron Carbonyl and Nickel Carbonyl. M. Berthelot, *Compt. rend., 112,* 1343-48 (1891). The reactions during their production are described, and a volatile combination of the two carbonyls is also discussed.

(1182) On Iron Carbonyls. L. Mond and C. Langer, *J. Chem. Soc. (London), 59,* 1090-93 (1891). The production of iron carbonyls is described.

(1183) Note on a Volatile Compound of Iron and Carbonic Oxide. L. Mond and F. Quincke, *Chem. News (London), 63,* 301; *64,* 20 (1891). The production of iron tetracarbonyl is described.

(1184) Nickel Carbonyl. M. Berthelot, *Bull. soc. chim., 7,* 431-434 (1892). The production of Ni carbonyl is reported.

(1185) Metallic Carbonyls. L. Mond, *Engineer,* 498 (1892). The paper on the production of nickel carbonyl presented by the author before the Royal Institution is discussed.

(1186) Nickel Carbonyl. L. Mond, *Proc. Roy. Inst., 13,* 668-76 (1893); *J. pharm. chim., 27,* No. 5, 575-81 (1893). The process of production of nickel tetracarbonyl is described and its uses are reviewed.

(1187) The History of My Process of Nickel Extraction. L. Mond, *J. Soc. Chem. Ind., 14,* 945-46 (1895). An account is given of the accidents leading to the discovery and identification of $Ni(CO)_4$.

(1188) Formation of Nickel-Carbon-Oxide. H. Frey, *Ber., 28,* 2512-14 (1896); *J. Soc. Chem. Ind., 15,* 199 (1896). A method for the production of nickel carbonyl is described.

(1189) Report on Tungsten. H. Moissan, *Compt. rend., 123,* 13-16 (1896). A description is given of the production of W_2C by the reduction of tungstic oxide with carbon in an electric furnace.

(1190) Preparation of Carbides. H. Moissan, *Compt. rend., 125,* 839-44 (1897). W_2O was produced by reducing tungstic oxide with calcium carbide in the electric furnace.

(1191) H. Moissan, *Le Four Electrique.* Steinheil, Paris, 1897, pp. 284-369. Production of carbides, silicides, and borides in powder form are discussed.

(1192) Production of Tungsten Carbide. P. Williams, *Compt. rend., 126,* 1722-24 (1898). A description is given of the production of a double compound of iron carbide and W_2C by reducing tungstic oxide with carbon in the presence of iron. WC was also produced.

(1193) Iron Carbonyl in Water Gas. M. van Breukeleveen and A. Horst, *J. Gasbeleucht, 42,* No. 44, 750 (1899); *Rec. trav. chim., 19,* 27-31 (1900). Iron carbonyl is formed when water gas comes into contact with iron.

(1194) Chemistry of Nickel Carbon Oxide. A. Mittasch, *Z. phys. Chem., 40,* 1-83 (1902). The production of $Ni(CO)_4$ is investigated and discussed.

(1195) The Constitution of Nickel Carbonyl. H. O. Jones, *Chem. News, 90,* 144-45 (1904). The chemical reaction for its formation is investigated.

(1196) A New Molybdenum Carbide. H. Moissan and M. K. Hoffmann, *Compt. rend., 138,* 1558 (1904). A mixture of Mo, C, and excess Al was heated in an electric furnace and the resultant Mo_2C is discussed.

(1197) A New Molybdenum Carbide. H. Moissan and M. K. Hoffmann, *Ber., 37,* 3324-27 (1904). The production and properties of Mo_2C are described.

(1198) Silicide of Tungsten. E. Defacoz, *Compt. rend., 144,* 848-50 (1907). A mixture of 180 g. silicon oxide, 45 g. tungstate, 250 g. sulfur, 200 g. Al powder is heated for an aluminothermic reaction.

(1199) Compound of Silicon and Molybdenum. E. Defacoz, *Compt. rend., 144,* 1425-1426 (1907). A mixture of 90% silicide of copper and 10% Mo is heated in an electric furnace. $MoSi_2$ forms crystals.

(1200) New Silicide of Platinum. P. Lebeau and A. Novitzky, *Compt. rend., 145,* 241-3 (1907). Si and Pt form a powdered compound SiPt and not $SiPt_2$.

(1201) Aluminum Carbide. C. Matignon, *Compt. rend., 145,* 676-78 (1907). A mixture of 24% C with 76% Al, mixed and wetted with turpentine, is heated, forming a fritted mass, in which the carbide particles are sprinkled throughout the predominant Al particles.

(1202) Preparation of Zirconium Carbide. E. Wedekind, *Chem. Ztg., 31,* No. 52, 654-655 (1907). Zr oxide is mixed with pure graphite, and the reduction takes place in an electric furnace. Zr carbide has a high conductivity.

(1203) Note on a Volatile Compound of Cobalt with Carbon Monoxide. L. Mond, H. Hirtz and D. M. Cowap, *Chem. News, 98,* 165 (1908). Finely divided Co and CO at 150° C. (300° F.) and subatmospheric pressure yielded small quantities of cobalt carbonyl; at 200° C. (390° F.) and below 100 atmospheres the yield was higher.

(1204) Titanium Carbide and New Class of Titanium Compounds, the Titanium and Nitrogen Halogenides. O. Ruff and F. Eisner, *Ber., 41,* 2250 (1908). Description of the production of various hard and rare metal compounds.

(1205) New Metallic Carbonyls. L. Mond, H. Hirtz and D. M. Cowap, *Proc. Chem. Soc., 26,* 67-69 (1910). A description of the production of $Co(CO)_3$ is given.

(1206) New Metal Carbonyls. L. Mond, H. Hirtz and D. M. Cowap, *Z. anorg. Chem., 68,* 207-19 (1910); *J. Chem. Soc., 97,* 798-99 (1910). The production of $Co(CO)_4$, $Ni(CO)_4$, and $Mo(CO)_6$ is described, and a discussion is presented of the use of high pressure in the preparation of nickel carbonyl.

(1207) Preparation of Tantalic Acid. E. Wedekind and W. Maas, *Angew. Chem., 23,* 2314-16 (1910). Treatment of tantalites and columbites with hydrofluoric and oxalic acids in the preparation of the fluorides as starting material for the production of the metal powders.

(1208) A Simple Preparation of Molybdenum and Tungsten Carbides. S. Hilpert and M. Ornstein, *Ber., 46,* 1669-1670 (1913). Finely powdered metals heated in mixtures of CO or CH_4 and H_2 (1:1) in resistance furnace. Mo in CO forms Mo_2C at 600 to 1000° C. (1100 to 1830° F.) at 800° C. (1470° F.) product varied between MoC and Mo_2C_3.

(1209) Iron in Gas. A. Stoffel, *Gas World, 59,* 178-180 (1913). A compound of Fe and CO called pentaferrocarbonyl is discussed. It is produced by passing CO at ordinary temperatures over powdered Fe.

(1210) Metallic Borides. E. Wedekind, *Ber., 46,* 1198-1200 (1913). A vacuum furnace is used and an arc produced between two rods composed of a mixture of the finely divided metal with amorphous boron.

(1211) O. Hönigschmid, *Karbide und Silizide,* Knapp, Halle, 1914. A large variety of hard compounds are discussed with a special view to their preparation and properties.

(1212) The Reaction Between Carbon Monoxide and Iron. A. Stoffel, *Z. anorg. Chem., 84,* 56-76 (1914). A study of the velocity of formation of $Fe(CO)_5$ from Fe and CO and the effect of various factors on the velocity is reported.

(1213) Metallurgy of Tungsten. J. L. F. Vogel, *Engineering, 110,* 415-6 (1920). The two main W ores, tungstates and scheelite (calcium tungstate), require different treatments, which are described. WO_3 concentrates are the result.

(1214) The Preparation of Nickel Carbonyl. E. Tassilly, H. Penau and E. Roux, *Bull. soc. chim., 29,* 862-5 (1921). If NiO is reduced by H at 400° C. (750° F.) and the resulting Ni treated with CO from the action of H_2SO_4 and NaOOCH or HCOOH, the best temperature for the reaction is 45° C. (113° F.) under a pressure of 3 cm. Hg.

(1215) Tungstates. G. Bessa, *Ind. chim., 9,* 2-6 (1922). Production of red tungstate; crystallization of sodium tungstate; washing and purifying of tungstic acid.

(1216) Chlorides of Bi-valent Molybdenum, Tungsten and Tantalum. K. Lindner, *Ber., 55,* 1458-65 (1922). Porcelain boats are filled with Mo powder and agitated with a stream of pure H, then with pure N, and then heated in phosgene at 800° C. (1470° F.) to form $MoCl_2$. Similar procedures are used for W and Ta chlorides.

(1217) Researches on the Metallic Carbonyls. R. L. Mond and A. E. Wallis, *J. Chem. Soc., 121,* 29-32 (1922). The composition of Mo carbonyl corresponds to $Mo_5(CO)_{26}$. Ruthenium gives two carbonyls, one volatile and the other non-volatile. Optimum conditions are described for the preparation of $Fe(CO)_5$, and the effect of the pressure-temperature conditions upon the rate of reaction is considered.

(1218) The Properties of Colloidal Tungstic Acid. L. Moser and J. Erlich, *Edel-Erden u. Erze, 3,* 49-51 (1922). Determination of the effect of various acids in precipitating tungstic acid from decinormal sodium tungstate ($Na_2WO_4.2H_2O$) solution.

(1219) Preparation of Organometallic Compounds. A. Job and R. Reich, *Compt. rend., 177,* 1439-41 (1923). A description of the preparation of $Ni(CO)_4$ is included.

(1220) Preparation of WO_2 and W_2O_5. J. A. M. van Liempt, *Z. anorg. allgem. Chem., 126,* 183-84 (1923). Description of the preparation of various tungsten oxides.

(1221) Electrolytical Production of Tungsten Chloride. D. Collenberg and A. Guthe, *Z. anorg. allgem. Chem., 134,* 317-26 (1924). $K_3W_2Cl_9$ is produced with a high yield by electrolytic reduction of a solution of K_2WO_4 in HCl.

(1222) Iron Carbonyl. E. Diepschlag, *Stahl u. Eisen, 44,* 1250-52 (1924). The production and uses of iron carbonyl are described.

(1223) Continuous Process for Manufacture of Sodium Tungstate and Tungstic Acid from Wolframite. N. T. Gordon and A. F. Spring, *Ind. & Eng. Chem., Ind. Ed., 16,* No. 6, 555-62 (1924). The mixture of ore and soda is conveyed to the rotary fusion furnace, and fused mass is discharged continuously into a leaching tank; the sodium tungstate is filtered.

(1224) Preparation and Properties of Nitrides. E. Friederich and L. Sittig, *Z. anorg. allgem. Chem., 143,* 293-299 (1925). The compounds TiN, VN, BN, Si_3N_4, TaN, ZrN, CbN and YN, YBN, ThN, UN were prepared.

(1225) Preparation and Properties of Carbides. E. Friederich and L. Sittig, *Z. anorg. allgem. Chem., 144,* 169-189 (1925). Carbides in powdered form: TiC, ZrC, VC, TaC, CbC, Cr_2C, Mo_2C, MoC, WC, SiC, Sc_4C_3, CaC_2.

(1226) A Carbonyl Compound of Gold. W. Manchot and H. Gall, *Ber., 58B,* 2175-8 (1925). By periodic arrangement of the metals which form carbonyl compounds, certain analogies are observed; the behavior of Au is particularly striking. CO unites with anhydrous $AuCl_3$ readily at 95° C. (203° F.); AuCl or AuBr may also be used, but with no advantage.

(1227) A Carbonyl Compound of Rhodium. W. Manchot and J. König, *Ber., 58B,* 2173-4 (1925). The union of CO with hydrated $RhCl_3$ proceeds readily at 140° C. (284° F.). Dark red needles of $Rh_2Cl_2O.3CO$ result which are water-soluble and melt at 125.5° C. (258° F.)

(1228) Preparation of a Chromium Carbonyl Through the Medium of a Magnesium Derivative. A. Job and A. Cassal, *Compt. rend., 183,* 392-4 (1926). By the action

of CO on C_6H_5MgBr, using $CrCl_3$ as a catalyst, the secondary product $Cr(CO)_6$ is obtained. It is a colorless compound, stable, and sublimes at room temperature. It does not catalyze the action of CO on the bromide. On heating above 200° C. (390° F.) it decomposes to Cr_2O_3, CO and Cr.

(1229) X-Ray Investigation of Diferro-Nonacarbonyl. R. Brill, *Z. Krist., 65,* 85-93 (1927). The crystallization of $Fe_2(CO)_9$ is investigated.

(1230) The Action of Carbon Monoxide on Phenylmagnesium Bromide in the Presence of Chromic Chloride. A. Job and A. Cassal, *Bull. soc. chim., 41,* No. 1, 814-24 (1927). CO reacts with PhMgBr only in the presence of small amounts of $CrCl_3$ to give addition products. One of the products obtained is chromium carbonyl.

(1231) Chromium Carbonyl. A. Job and A. Cassal, *Bull. soc. chim., 41,* No. 2, 1041-6 (1927). Chromium carbonyl has been prepared with a 22% yield by dropping a Grignard reagent into a suspension of $CrCl_3$ in a mixture of ether and benzene in a CO atmosphere; the optimum temperature is between 0 and 4° C. (32 and 39° F.).

(1232) Iron Carbonyls. N. Langeron, *Rev. universelle mines, 16,* 145-61 (1927). The production and properties of iron carbonyls are described. A bibliography is included.

(1233) Tungsten Carbides and Their Applications. F. Skaupy, *Z. Elektrochem., 33,* 487-491 (1927). The products are obtained by heating W powder and are examined by chemical analysis and by X-ray method. W_2C and WC are recognized.

(1234) Reactivity and Derivatives of Iron Carbonyl. W. Hieber and G. Bader, *Ber., 61,* 558-61, 1717-22, 2421-27 (1928). The production of carbon oxide compounds of iron halogenides are described.

(1235) Preparation of a Tungsten Carbonyl by the Intermediary of Magnesium Derivative. A. Job and J. Rouvillois, *Compt. rend., 187,* 564-5 (1928). By methods which have been used for the preparation of chromium carbonyl [*Compt. rend., 183,* 392-4 (1926)], tungsten carbonyl, $W(CO)_6$, was prepared from WCl_6. The colorless crystalline carbonyl is slightly soluble in C_2H_6 and C_6H_6. It sublimes at 50° C. (122° F.). The same method is given for the preparation of $Mo(CO)_6$.

(1236) History of Tungsten Minerals and Metals. E. Rothelius, *Blad Bergshandt. Vanner, 19,* 141-147 (1928). It is stated that the largest and richest tungsten ore deposits are in Asia.

(1237) Method for the Production of Pure Copper Sulphide. K. Fischbeck and O. Dorner, *Z. anorg. allgem. Chem., 182,* 228-34 (1929). Copper oxalate is mixed with carbon disulfide, during stirring sulfur dissolved in carbon disulfide is added; the reaction product is agitated with steam, and then washed out with carbon disulfide.

(1238) Synthesis of Metallic Carbonyls. G. Gallas and A. Alonso, *Anal. soc. espan. fis. quim., 27,* 663-7 (1929). $Ni(CO)_4$ was prepared by the action of CO on Ni obtained by reduction of the oxalate of H_2 by the Brochet method. The carbonyl was received in xylene, and the xylene solution used for synthesis of organic compounds.

(1239) Titanium and Hydrogen. L. Kirschfeld and A. Sieverts, *Z. physik. Chem., A 145,* 227-240 (1929). Titanium tetrachloride was distilled together with sodium, cleaned, and agitated with hydrogen at different temperatures to yield titanium hydride.

(1240) Formation of Nickel Carbonyl. W. Manchot and H. Gall, *Ber., 62B,* 678-81 (1929). A new method of producing nickel carbonyl by the introduction of carbon monoxide into the reaction vessel is described.

(1241) Metal Carbonyls. R. L. Mond, *Chim. et ind., 21,* 681-700, 937-40 (1929). An address reviewing the preparation, properties and applications of metallic carbonyls, with a bibliography of 91 references to articles, and 69 references to patents.

(1242) Iron Carbonyl. H. Pincass, *Chem. Ztg., 53,* 525-6 (1929). A recent I. G. Farbenindustrie A.-G. process uses Fe ore and CO from producer or water gas,

with at least 5% H present, with temperatures near 500° C. (930° F.) and pressures near 200 atmospheres.

(1243) World Tungsten Raw Material Access. H. Carlborg, *Jernkonterets Ann., 85,* 455-90 (1930). Contains information on Scheele's method of producing tungstic oxide from calcium tungstate in 1781.

(1244) Metal Carbonyls. R. L. Mond, *J. Soc. Chem. Ind., 49,* 271T-8T, 283T-4T, 287T-90T (1930). A review of the preparation, properties, and applications of metallic carbonyls.

(1245) Molybdenum Trioxide. J. Feiser, *Metall u. Erz, 28,* No. 12, 297-302 (1931). Production and properties are investigated.

(1246) Methods for the Production of Pure Carbides, Nitrides and Borides. K. Moers and C. Agte, *Z. anorg. allgem. Chem., 198,* 233-275 (1931). Sintering and thermal dissociation methods are used for the production of these compounds.

(1247) Apparent Formation of Copper Carbonyl. E. H. Boomer, H. E. Morris and G. H. Argue. *Nature, 129,* 438 (1932). An apparent formation of Cu carbonyl was noted in the synthesis of methyl alcohol with a catalyst containing copper.

(1248) The Preparation of Metal Carbonyls. S. S. Urazovskii, *J. Chem. Ind.,* No. 5, 23-8 (1932). The optimum condition for the preparation of $Ni(CO)_4$ at atmospheric pressure is the passage of CO over Ni freshly reduced on pumice at the rate of 1.5 liters per minute at 45-50° C. (113-122° F.).

(1249) K. Becker, *Hochschmelzende Hartstoffe und ihre technische Anwendung.* Verlag Chemie, Berlin, 1933. Manufacture, chemical and physical properties of hard metals and alloys.

(1250) Iron Carbonyl Hydride. W. Hieber and H. Vetter, *Z. anorg. allgem. Chem., 212,* 145-68 (1933). The production and properties of the carbonyl and its hydride are described.

(1251) Oxygen and Halogen Compounds of Rhenium. I. Noddack and W. Noddack, *Z. anorg. allgem. Chem., 215,* 129-84 (1933). The production and the properties of the compounds are described.

(1252) Nickel Carbonyl - Mechanism of Its Formation from Nickel Sulfide and Carbon Monoxide. M. M. Windsor and A. A. Blanchard, *J. Am. Chem. Soc., 55,* 1877-83 (1933). $Ni(CO)_4$ may be formed by the dissociation of NiS or NiS_2 in the presence of a sulfide-removing agent.

(1253) Formation of Carbonyls and Related Compounds. A. A. Blanchard, J. R. Rafter, and W. B. Adams, *J. Am. Chem. Soc., 56,* 16-17 (1934). Carbonyls of Ni and Co were prepared by the treatment of alkaline suspensions of sulfide or cyanide with CO.

(1254) Formation of Cobalt Carbonyl. W. Hieber, *Z. Elektrochem., 40,* 158-59 (1934). The chemical formation process is described.

(1255) Precipitation of Titanium Phosphate. T. Da-Tchang and H. Li, *Compt. rend., 200,* 2173-5 (1935). The influence of the acidity and the concentration of ammonium phosphate in the titanium bearing solution are investigated.

(1256) Metal Hexacarbonyls of the Chromium Group, Their Formation and Reaction Mechanism. W. Hieber and E. Romberg, *Z. anorg. allgem. Chem., 221,* 321-31 (1935). Hexacarbonyls of Cr, Mo and W were prepared by the action of CO upon the metal chloride in the presence of Grignard's Mg compound under total exclusion of O and H_2O at 0-5° C. (32-41° F.) under vigorous agitation.

(1257) Iron Carbonyl, Its Formation and Action in City Gas. L. Kaatz and H. E. Richter, *Gas u. Wasserfach, 78,* 351-5 (1935). Sooting up and stoppage of gas mantle lamps was found to be due to iron carbonyl, formed during the protracted storage of blue gas in a gas holder at ordinary distribution pressure.

(1258) Carbide of Tantalum.. R. Genders and R. Harrison, *J. Iron Steel Inst., No. II,* 203-04 (1936). TaC is prepared from a mixture of ferro- tantalum and carbon which is melted in an induction furnace and then cooled. It is then crushed and milled and after leaching with HCl, the insoluble TaC (containing CbC) is mixed with the required amount of carbon and heated in pure hydrogen to 1600-1700° C. (2900-3100° F.).

(1259) Recent Developments in the Field of Metal Carbonyls – Metal-Hydrocarbonyls. W. Hieber, *Angew. Chem., 49,* 463-4 (1936). Description of production and properties of iron and cobalt hydrocarbonyls and chromium and nickel carbonyls.

(1260) Preparation of Ruthenium Carbonyls and Nitrosyls. W. Manchot and W. J. Manchot, *Z. anorg. allgem. Chem., 226,* 385-415 (1936). To prepare ruthenium pentacarbonyl, $Ru(CO)_5$, Ru black, obtained by reduction of $RuCl_3$ with hydrazine sulfate and NaOH, is caused to react in a Ag- or Cu-coated autoclave with CO for 14 days at 300° C. (570° F.) and 400 atmospheres pressure. $Ru(CO)_5$ is a colorless, very volatile liquid having a melting point -22° C. (-8° F.). It is very sensitive to light, which caused evolution of CO and the production of orange-red, pseudohexagonal plates of $Ru_2(CO)_9$.

(1261) Metal Carbonyls - Constitution and Properties. W. E. Trout, Jr., *J. Chem. Education, 14,* 575-81 (1937). History of the development of carbonyls.

(1262) The Hydride Process - I. P. P. Alexander, *Metals & Alloys, 8,* No. 9, 263-64 (1937). New hydrides discovered; production and properties of calcium hydride; reduction of refractory oxides.

(1263) The Volatile Metal Carbonyls. A. A. Blanchard, *Chem. Rev., 21,* 3-38 (1937). A review of the preparation, structure, and properties of the volatile metal carbonyls is given.

(1264) Production and Properties of Titanium Monoxide. W. Dawihl and K. Schröter, *Z. anorg. allgem. Chemie, 233,* No. 2, 178-183 (1937). The crystalline titanium monoxide produced by reduction of titanium dioxide with Ti is an independent compound, and not a mixture of different Ti compounds.

(1265) Metal Carbonyls. W. Hieber, *Z. Elektrochem., 43,* 3907 (1937). Review of the discovery, technical preparation, constitution and chemistry of carbonyls. New methods of preparation are described and include the formation of metal carbonyls from carbonyl halides and preparation of carbonyl in the liquid way.

(1266) Preparation of Nickel Tetracarbonyl. K. Mayer and J. P. Wibaut, *Rec. trav. chim., 56,* 356-8 (1937). $Ni(NO_3)_2.6H_2O$ was treated with oxalic acid and sulfuric acid, and a slow stream of CO was passed over the resulting $NiC_2O_4.2H_2O$ for 2 hours at 450° C. (840° F.). Upon cooling the gaseous mixture, $Ni(CO)_4$ was condensed in a receiver cooled with a mixture of CO_2 and ethyl alcohol.

(1267) Nickel Carbonyl Now Available. *Ind. Eng. Chem., News Ed., 16,* 327 (1938). Production of nickel carbonyl is discussed.

(1268) The Hydride Process – II. P. P. Alexander, *Metals & Alloys, 9,* No. 2, 45-48 (1938). Production and properties of titanium hydride are described.

(1269) The Hydride Process – III. P. P. Alexander, *Metals & Alloys, 9,* No. 7, 179-81 (1938). Early work on hard titanium compounds. Hardness of titanium silicides. Titanium silicides by hydride process. Hydrides as source of pure hydrogen.

(1270) Conditions of Formation and the Stability of Carbonyls and Complex Cyanides. B. Ormont, *J. Phys. Chem., 12,* 259-70 (1938). The applicability of Ormont's three rules to the case of carbonyls and complex cyanides is investigated in detail. Elements, such as Cr, which form more stable carbonyls should form unstable cyanides relatively frequently, while those like Co yield unstable carbonyls and very stable cyanides.

(1271) Metal Carbonyls. W. E. Trout, Jr., *J. Chem. Ed., 15,* 77-83 (1938). This is a general review of the subject, covering production methods in particular.

(1272) Production of Titanium and Tungsten Carbides. *Inco, 16,* No. 3, 9-10 (1939); *Met. Abstracts,* 6, No. 12, 564 (1939). Briefly describes the production of Ti- and W-carbides for hard alloys, by synthesis in a bath of pure nickel at 2200° C. (4000° F.)

(1273) Ferromagnetic Compounds of Chromium. L. F. Bates and G. G. Taylor, *Proc. Phys. Soc., 51,* Part I, No. 283, 33-6 (1939). When chromium powder prepared from chromium amalgam is heated with S in vacuo a series of ferromagnetic compounds is formed. The Curie point and the magnetization of the specimens are recorded.

(1274) High-Pressure Synthesis of Cobalt Carbonyl and Cobalt Carbonyl Hydride From Cobalt Compounds. W. Hieber, H. Schulten and R. Marin, *Z. anorg. allgem. Chem., 240,* 261-72 (1939). If dry CoS is heated for 12 hours at 190° C. (375° F.) in CO at a pressure of 250 atmospheres in a rotating autoclave, $[Co(CO)_4]_2$ is obtained. If anhydrous CoI_2 is heated in CO at 145 atmospheres for 12 hours at 160° C. (320° F.), a quantity yield of the tetracarbonyl is obtained. $HCo(CO)_4$ is formed by the action of CO and H on dry Co salts, Co carbonyl or metal.

(1275) The Mechanism of the High-Pressure Synthesis of Cobalt Carbonyl from Cobalt Halides. W. Hieber and H. Schulten, *Z. anorg. allgem. Chem., 243,* 145-63 (1939). When the Co halides were heated for 15 hours with CO under a pressure of 200 atmospheres in a container lined with Ag or Cu, the halogen was precipitated as AgX or CuX and $Co(CO)_4$ was produced. The chloride gave a yield of 4.5% $Co(CO)_4$ at 300° C. (570° F.), the bromide gave 4.5% at 200° C. (390° F.), but the iodide gave 100% at 150° C. (300° F.).

(1276) Autoclave Process of Extraction of Tungsten from Concentrates. I. N. Maslenitskii, *Tsvetnye Metal. 14,* No. 4-5, 140-3 (1939) (in Russian); *Metals & Alloys, 11,* No. 2, Ma 72 (1940). Extraction of W from solutions gave precipitates containing 50-68% WO_3. Scheelite used as raw material.

(1277) Conditions for the Formation and the Stability of Carbonyls and Complex Cyanides. B. Ormont, *Acta Physicochim., 11,* 585-602 (1939). Cf. item **1270.**

(1278) Preparation of Cobalt Carbonyl, Cobalt Nitrosyl Carbonyl and Cobalt Carbonyl Hydride by the Cyanide Method. A. A. Blanchard and P. Gilmont, *J. Am. Chem. Soc., 62,* 1192-3 (1940). An alkaline suspension of a cobalt salt absorbs CO almost quantitatively to form $KCo(CO)_4$, but only in the presence of a carrier such as a small amount of a cyanide.

(1279) Iridium Carbonyl. W. Hieber and H. Legally, *Z. anorg. allgem. Chem., 245,* 321-33 (1940). Anhydrous $IrCl_3$ was heated for 1-2 days at 140° C. (285° F.) with CO under 350 atmospheres pressure. The product was $Ir(CO)_3$ with a little $Ir(CO)_4$. $IrBr_3$ and IrI_3 reacted similarly and required a lower temperature.

(1280) Carbonyls of the Metals of the Sixth Group of the Periodic System. (In English). K. A. Kocheshkov, A. N. Nesmeyanov, M. M. Nad , I. M. Rossinskaya, and L. M. Borisova, *Compt. rend. acad. sci., U. R. S. S., 26,* 54-7 (1940). The hexacarbonyls of Cr, Mo and W from the chlorides together with CO were successfully prepared by using Zn or Fe dust, as reducing agent, in place of the Grignard reagent.

(1281) Carbonyls of the Metals of the Sixth Group of the Periodic System. (In English). A. N. Nesmeyanov and K. N. Anissimov, *Compt. rend. acad. sci., U. R. S. S., 26,* 58-9 (1940). The yields of the hexacarbonyls can be increased by carrying out the reaction in an autoclave at increased pressure. With an initial pressure of 100-200 atmospheres the yield of W carbonyl was 70%; with an initial pressure of 90 atmospheres the yield of Mo carbonyl was 40%. Temperature has little effect at these pressures, the reactions being carried out at room temperature.

(1282) The Formation of Iron Carbonyl in the Action of Carbon Monoxide upon Steel. H. Pichler and H. Walenda, *Brennstoff-Chem., 21,* 133-41 (1940). Literature is reviewed in work arising from the projected use of CO and H with alloy steels at 300° C. (570° F.) and 1000 atmospheres.

(1283) The Quality of Sintered Iron Ore. I. E. Timchuk, S. I. Rostovtsev, and G. I. Volkovitskii, *Teoriya i Prakt. Met., 12,* No. 5-6, 5-11 (1940). Sinter of more uniform size obtained by control of sintering operation.

(1284) Addition of Manganese Ore to the Sinter Layer. I. E. Timchuk, *Teoriya i Prakt. Met., 12,* No. 7, 12-13 (1940). 4-5% Mn added to Fe ore gives optimum results.

(1285) Sintering of Fine Chromium Ores. G. I. Volkovitskii and S. I. Khitrik, *Teoriya i Prakt. Met., 12,* No. 10, 24-30 (1940). Cr ore converted to C-free sinter with 75% ferrosilicon or fine coke as fuel.

(1286) Metal Carbonyls. A. A. Blanchard, *Science, 94,* 311-17 (1941). In the main, a review of metal carbonyls and derivatives of metal carbonyls.

(1287) Rhenium Pentacarbonyl. W. Hieber and H. Fuchs, *Z. anorg. allgem. Chem., 248,* 256-68 (1941). Rhenium carbonyl can be formed from Re_2O_7 and CO in 16 hours with an initial pressure of approximately 200 atmospheres of CO at 250° C. (480° F.). The pentacarbonyl, $Re(CO)_5$, which is obtained in quantity yields, consists of colorless crystalline leaves of typical carbonyl character and can be recrystallized from organic solvents and sublimed. $KReO_4$ can be converted directly into $Re(CO)_5$.

(1288) Investigation of the Condition of Titanium Carburization. G. A. Meerson, and Ya. M. Lipkes, *J. Applied Chem. (U. S. S. R.), 14,* No. 3, 291-301 (1941). Mixtures of powdered TiO_2 and lampblack were heated in H_2 and CO at atmospheric pressure. Maximum carbon saturation could be obtained by raising the temperature, without keeping the material at a critical temperature at which further heating lead to a loss of carbon. In the cylindrical crucible furnace type used, this critical temperature was established to be 1900° C. (3450° F.). The titanium carbide powder thus produced contained 19.0-19.5% combined and less than 0.5% free carbon.

(1289) Hydride Process and Its Products. P. P. Alexander, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chapter 12, 145-54. The hydride process is used for producing various hydrides; utilization of their properties in the production of pure metals and alloys, and in the generation of pure active hydrogen.

(1290) The Present Status of the Chemistry of Metal Carbonyls. W. Hieber, *Die Chemie, 55,* 7-11, 24-8 (1942). The history of metal carbonyls, their direct synthesis and recent methods of their production are reviewed.

(1291) The Formation of Iron, Cobalt and Nickel Carbonyls from the Halides by High-Pressure Synthesis under Comparable Conditions. W. Hieber, H. Behrens and U. Teller, *Z. anorg. allgem. Chem., 249,* 26-42 (1942). When FeI_2 is heated for 15 hours at 200-250° C. (390-480° F.) with CO at 200 atmospheres at room temperature in a copper-lined vessel, a 50-75% yield of $Fe(CO)_5$ is obtained, along with a smaller amount of $Fe(CO)_4I_2$. With $FeBr_2$ or $FeCl_2$, under the same conditions, only traces of $Fe(CO)_5$ are formed.

(1292) Tungsten. C. Hileman, *Bol. informaciones petroleras, 19,* No. 219, 23-46 (1942). A review with detailed discussion of the occurrence and mining of W ores in Argentina. Ore concentration, preparation of WO_3 are described.

(1293) Tungsten — An Important War Material. D. C. McLaren, *Mining Congr. J., 28,* No. 7, 29-33 (1942). The interest in exploiting deposits for war effort makes notes on W ores more in demand both in U.S. and Canada. Flow sheet of W recovery plant with low and high amperage magnetic separation. Ball milling and concentration of WO_3 are described.

(1294) Physical and chemical Phenomena in the Sintering of Iron Ores. F. Hartmann, *Stahl u. Eisen, 63,* No. 20, 393-8 (1943). Requirements of sinter, temperature measurements, influence of lime additions on temperature, structural analysis, etc.

(1295) Osmium Carbonyls. W. Hieber and H. Stallmann, *Z. Elektrochem., 49,* 288-92 (1943). Studies on the high-pressure synthesis of Os carbonyls have shown that the carbonyls can be made *(1)* by the action of metals such as Ag or Cu on Os halides in the presence of Co under high pressure; *(2)* by the direct action of CO under high pressure on OsO_4.

(1296) Processing of Tantalite Ores and Preparation of Carbides of Ta and Cb. R. H. Myers and J. N. Greenwood, *Proc. Australasian Inst. Min. Met., 129,* 41-53, (1943). Best deposits of Ta and Cb in Northwest Australia. Processing, extraction of oxides, preparation of carbides.

(1297) The Metal Carbonyls and Their Significance in Chemistry and Industry. P. G. Spacu, *Rev. Stiintifica "V. Adamachi", 29,* 116-37 (1947), *Chem. Zentr., II,* 2232 (1943). A review with many references, of the history, industrial and laboratory preparations, constitution, chemical and physiological reactions, and uses of the carbonyls of Cr, Fe, Co, Ni, Mo, Ru, W, R, Os and Ir.

(1298) Concentrator for Tungsten Ore. J. G. Hart, *Proc. Australasian, Inst. Min. Met.,* No. 136, 1-82 (1944). Scheelite contains Mo in lattice structure and the final concentrates contain 1-2% Mo, inseparable by ore-dressing methods.

(1299) Two New Carbonyls: Copper and Tellurium. P. L. Robinson and K. R. Stainthorpe, *Nature, 153,* 24-5 (1944). $Cu(CO)_3$, obtained by the reaction of CO with hot CuO, is a white solid, sublimes readily, and is probably dimeric. TeCO, obtained by the action of CO on Te, is a gas; it is somewhat less stable than is carbonyl selenide.

(1300) Molybdenum Ore – Testing Program. R. E. Cuthbertson, *Mining and Met., 27,* No. 474, 346-49 (1946). Investigation of dressing of Mo ore in a plant of Colorado School of Mines is described. Fine grinding with steel balls contaminates MoS_2 with Fe and reduces the recovery. Elimination of Cu is obtained by leaching with NaCN solution.

(1301) Mining of W Ore at Aberfoyle (Tasmania). H. H. Dunkin, *Chem. Eng. Mining Rev., 38,* 241-250, 283-290 (1946). Methods and results of treating SnO_2 and WO_3 ore and the plant are described.

(1302) Chlorination of Tungsten Ores. Ya. D. Fridman and Yu. Bogoraz, *J. Applied Chem. (U. S. S. R.), 19,* 833 (1946); *C. A., 41,* No. 14, 4421 (1947). Chlorination at 100° C. (212° F.) for 1 hr. of a scheelite concentrate with 11% WO_3 with various fractions of liquid sulfur-chlorides gave highest yields in W-chloride.

(1303) Calcium Hydride. E. E. Halls, *Ind. Chem., 22,* No. 262, 680-85 (1946). A summary of literature concerned with the preparation and industrial application of calcium hydride is given.

(1304) Effects of Lime Addition to Iron Ore Sinters. J. M. McLeod, *J. West Scot. Iron Steel Inst., 54,* 197-200 (1946). Sintered samples made with 10% lime gave 90% reduction of their Fe in half the time required by samples containing no lime.

(1305) Copper Carbonyl. D. A. Pospekhov, *J. Applied Chem. (U. S. S. R.), 19,* 848-9 (1946). Formation from Cu, H_2 and CO of a Cu carbonyl hydride, $Cu(CO)_3H$, sensitive to oxidation, is possible.

(1306) Evidence for the Formation of a Copper Carbonyl. H. Bloom, *Nature, 159,* 539 (1947). An experiment is described which is intended to prove the formation of a copper carbonyl. The reaction between Cu and CO at temperatures between 250-400° C. (480-750° F.) is proved by the deposition of a copper mirror on a glass combustion tube when CO was passed through the tube which contained a roll of copper gauze.

(1307) Preparation of Carbides. L. D. Brownlee, G. A. Geach and T. Raine, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 75-78; *Met. Powd. Rept. 1,* No. 11, 167 (1947). Authors studied the systems TaC-WC and TaC-TiC and found that in TaC-WC exists a solid solubility of 27% of W-carbide in Ta-carbide at 2000° C. (3630° F.).

(1308) Formation of Uranium Hydride. J. E. Burke and C. S. Smith, *J. Am. Chem. Soc., 69,* 2500 (1947). Uranium hydride formed as fine highly pyrophoric powder by passing hydrogen over uranium wire.

(1309) Molybdenum and Vanadium Ores in France. V. Charrin, *Chimie & industrie, 58,* 608 (1947). Molybdenum and vanadium are known to occur in France but the ores are not being worked at present.

(1310) Production of Molybdenite and Bismuth at La Corne, Quebec . F. K. McKean, *Trans. Can. Inst. Mining Mets., 50,* 375-380 (1947). Crushed molybdenite ore ground to 30% minus 200 mesh results in a concentrate assaying MoS_2 80.7%, Bi 3.82%, Fe 0.95%, Cu 0.75%.

(1311) Dressing of Tungsten Minerals. F. B. Mitchell, *Mine & Quarry Eng., 36,* 169-171 (1947). General treatment of tungsten ores; chemical treatments, magnetic separation, removal of sulfides are discussed.

(1312) The Synthesis of Chromium Hexacarbonyl. B. B. Owen, J. English, Jr., H. G. Cassidy, and C. V. Dundon, *J. Am. Chem. Soc., 69,* 1723-5 (1947). A procedure is given by which approximately 60% yields of chromium hexacarbonyl can be obtained by the action under pressure of CO upon PhMgBr and $CrCl_3$ in dry ether.

(1313) Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3753/47 (1947). According to this report of 1936, tungsten can be carburized with

lampblack at 1250-1300° C. (2280-2370° F.) in 45 min. Such carbide can be sintered at 1350-1400° C. (2460-2550° F.) to give the same results as normal carbide sintered at 1450° C. (2640° F.).

(1314) Silicon Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3759/47 (1947). In 1937, silicon carbide was fractionated by centrifuging in glycerine.

(1315) Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3760/47. (1947). According to this report, dating from 1937, WC-TiC scrap was recovered by heating to 1800° C. (3270° F.) in a carbon tube furnace, crushing and dry grinding for 100 hours. Tips made from this material were more porous and had coarser grain than originally, and gave a 40% lower efficiency.

(1316) Tungsten Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3778/47 (1947). According to this report of 1937, mixtures of tungsten, titanic acid, vanadic acid and lampblack could not be simultaneously carburized and sintered, as claimed in an unspecified patent application. The products were not suitable for hard metal purposes.

(1317) Boron Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3806/47 (1947). This report of 1939 shows that boron carbide reacts with Ti, W, Mo, and Fe. For example, 100 parts titanium and 22 parts boron carbide for an 80/20 titanium boride-titanium carbide according to the formula: $B_4C + 5\ Ti = 4\ TiB + TiC$. This may represent an economical method of obtaining borides.

(1318) Scheelite for Production of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3816/47 (1947). Instructions for direct carburization of scheelite to WC, dating from 1939.

(1319) Manufacture of Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3817/47 (1947). According to this report of 1940, free carbon in TiC can be removed by treatment with 400-500% excess manganese powder according to Ger. Pat. 680,566 of the I. G. Farbenindustrie but some of the Mn remains in the carbide.

(1320) Manufacture of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3818/47 (1947). Manufacture of WC from tungsten/graphite, tungstic acid/lampblack, tungstic acid/graphite, direct from scheelite and from wolframite is described in reports dating from 1937-39.

(1321) Titanium Carbide Crystals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3833/47 (1947). The report, dating from 1940, shows that at temperatures above 1800° C. (3270° F.) angular TiC crystals are precipitated from TiC-Co. It is suggested that the Co should be leached out and tool tips be made from the angular TiC crystals.

(1322) Tungstate. Studiengesellschaft Hartmetall. F. D. Rept. No. 3858/47 (1947). Ammonium para-tungstate could be precipitated from sodium tungstate solutions by means of ammonium chloride or nitrate with yields of approximately 80%.(Report dates from 1941.)

(1323) Calcium Tungstate. Studiengesellschaft Hartmetall. F. D. Rept. No. 3904/47 (1947) According to this report of 1941, tungsten from calcium tungstate gives carbides of the same quality as that of other origin.

(1324) Multiple Carbides Preparation. Studiengesellschaft Hartmetall. F. D. Rept. No. 3920/47 (1947). In WC-TiC solid solutions the WC cleans up the TiC, *i. e.*, displaces oxygen atoms in the TiC. It may, therefore, be preferable to prepare WC-TiC only with sufficient WC to displace the TiO, the amount being determined from lattice constant measurements. This alloy would then be ground and the remaining WC added. (Report dates from 1942.)

(1325) Part 1. Preparation of Boron Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3935/47 (1947). Fine-grained boron carbide of uniform purity was prepared in 1942 by reducing boric acid with Mg in a hydrogen atmosphere at 900° C. (1650° F.), leaching with HCl, and carburizing the boron with lampblack at 1430-2100° C. (2600-3810° F.) for 1 hour, the particle size of the boron carbide increasing with the carburization temperature. The purity can be increased from 91-97% by subsequent vacuum heating at 1800° C. (3270° F.). An alternative method for large-scale work was to heat the boric acid - Mg mixture with 20% lampblack at 1900° C. (3450° F.) followed by rapid cooling and leaching.

(1325 A) Part 2. Particle Growth of Boron Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3935/47 (1947). According to this report of 1943, the particle growth of boron carbide is accelerated, *i. e.*, occurs at lower carburization temperatures, by using purer starting materials, *e. g.*, the boron contains less impurities when fine magnesium powder is used. A fine boron carbide was again obtained by using coarse magnesium and working with refractory crucibles under less carefully controlled conditions.

(1326) Vanadium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 4004/47 (1947). Preparation of vanadium carbide. (Report dates back to 1937).

(1327) Large-Scale Production of Metal Hydrides. H. W. Zabel, *Chem. Inds., 60,* No. 1, 37-38 (1947). Production, properties and uses in chemical and metallurgical industries are described. Hydrides are useful in the preparation of powdered Cr alloys.

(1328) Recovery of Lithium from Ores and Salts. J. B. Cunningham and C. H. Gorski, *U. S. Bur. Mines Rept. Invest. No. 4321,* 1948, 35 pp. Initial tests with a sintering charge of 50% amblygonite, containing 8-9% Li_2O, 42.6% gypsum, 25% lime indicated that the highest recovery of 80% Li was obtained with 2 hrs. sintering time at 510° C. (950° F.); the sinter was then leached.

(1329) Metallurgical Improvements in Treatment of Copper-Nickel Ores. International Nickel Co. of Canada, Ltd. *Trans. Can. Inst. Mining Met., 51,* 356-360 (1948). Series rod-ball grinding now established. The Cu-Ni content of the flotation tailings is cut in half. A process is under development to produce a Ni oxide sinter for market from the converter material.

(1330) Roasting Molybdenum Concentrates. K. N. Kadarmetov and K. N. Rispel, *Stal, 8,* 81-89 (1948). Carried out in a channel coal-fired reverberatory furnace, charged through the roof and concentrates moved through four zones of the furnace, corresponding to its four ports; the temperature is increased from 450 to 710° C. (840-1310° F.).

(1331) By-Products Obtained in Refining Aluminum Scrap. K. Schneider, *Metall, 1,* 35-36 (1948). Cutting fluids are reclaimed from Al chips by centrifuging. Ball-mill dust containing Al_2O_3 can be used for abrasives and grinding wheels; also as catalysts, or as raw material for $AlFe_3$ or cryolite.

(1332) Production of Magnetic Iron Oxide Powder. *Iron Coal Tr. Rev., 158,* No. 1, 63 (1949). The Indiana Steel Products Co. has prepared a magnetic iron oxide powder by the Raney method for production of permanent magnets.

(1333) Titanium Investigation: Research and Development Work on Preparation of Titanium Chloride and Oxide from Titanium Mattes. R. G. Knickerbocker, C. H. Gorski, H. Kenworthy and A. G. Starliper, *Trans. Am. Inst. Mining Met. Engrs., ?,* 785-91 (1949). In a search for a cheaper starting material than purified Ti tetrachloride for the Kroll process, the U. S. Bur. Mines has been doing some laboratory work on the treatment of either rutile or ilmenite with pyrites and coke.

(1334) Experimental Production of Pure Titanium-Carbide Powder by Means of Carbonizing Gases. V. Fattinger, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chap. 17, pp. 295-302. The reaction between titanium dioxide and carbon can be catalyzed very effectively by adding carbon tetrachloride or chloroform to the reducing gas (hydrogen), with reaction rates and quality of the end product being superior to the ones obtainable by the conventional vacuum treatment.

D. Semi- and non-metal powders (carbon, boron, silicon)

(1335) Boron: Its Properties and Preparation. E. Weintraub, *J. Ind. Eng. Chem., Ind. Ed., 5,* 106-115 (1913). Boron powder of 99% purity is obtained by reduction of the oxide with magnesium at high temperatures. The powder is suitable for pressure sintering into compacts.

(1336) Synthetic Carbon. W. Stockmeyer, *Feinmechanik u. Präzision, 51,* 205-8, 241-7 (1943). Production, properties and applications are described for various grades and types of carbon, including carbon black and graphite powders.

(1337) U. S. to Investigate German Methods of Producing Cerium. *Iron Age, 157,* No. 25, 100 (1946). Germans have achieved 20% higher extraction of cerium metal from monazite sand as compared with extraction in the United States.

3. PROPERTIES AND BEHAVIOR OF METALS, ALLOYS, AND COMPOUNDS IN POWDER FORM

(1338) Specifications and Tests for Zinc Dust. A. M. Merton, *Mining Eng. World, 38,* 1227-8 (1913). The precipitation of Zn powder dust depends not merely on the percentage of metallic Zn, but also upon the fineness of the particles. The measuring of the particles would require elaborate tests and apparatus far beyond the needs of a mill.

(1339) The Nature of Zinc Dust. O. Ravner, *Chem. Met. Eng., 24,* 932-4 (1921). Analyses of Zinc dust. Physical properties. Briquetting experiments. Chemical properties.

(1340) The Properties of Metal Hydrides — I. A. Sieverts and A. Gotta, *Z. anorg. allgem. Chem., 172,* 1-31 (1928). Experiments with different metal hydrides are described, and the rates of decomposition are given for different temperatures. The densities of Ti and TiH, ZrH, VH and CrH are investigated.

(1341) The Properties of Some Metal Hydrides — II. A. Sieverts and A. Gotta, *Z. anorg. allgem. Chem., 187,* 155-64 (1930). Continuation of paper in *Z. anorg. allgem. Chem., 172,* 1-31 (1928) by same authors. The densities of ZrH and TaH are measured.

(1342) The Properties of Some Metal Hydrides — III. A. Sieverts and A. Gotta, *Z. anorg. allgem. Chem., 199,* 384-386 (1931). Titanium hydride is treated in this continuation paper.

(1343) A Course of Instruction in Micromeritics. J. M. Dallavalle, *J. Chem. Education, 20,* No. 6, 557-61 (1943). Study of physical properties and behavior of small metallic particles in the visible range.

(1344) Magnetic Powders. H. G. Shea, *Electronic Ind., 4,* No. 8, 86-88 (1945). Many physical and chemical characteristics bear on the usefulness of metallic and compound iron powder.

(1345) Metallic Powders. *Métallurgie et Construction Mechanique, 78,* No. 11, 15-21 (1946). Physical and chemical properties of metal powders are reviewed.

(1346) Iron Powder. *Iron & Steel, 20,* No. 4, 136 (1947). Chemical analysis and physical properties of new high quality hydrogen annealed Swedish sponge Fe powder is given.

(1347) Some Properties of Iron Powders. C. J. Leadbeater, L. Northcott, and F. Hargreaves, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 15-36; *Met. Powd. Rept., 1,* No. 6, 91-94 (1947). The properties of 28 commercial iron powders, together with those of compacts prepared from them by a simple pressing and sintering technique, have been determined. The majority of the powders were prepared by either the oxide-reduction or electrolytic methods, but individual samples of the carbonyl, abrasion, and chloride-reduction methods were included in the investigation.

(1348) J. M. Dallavalle, *Micromeritics: The Technology of Fine Particles.* 2nd Ed., Pitman, New York, 1948; 555 pp. Dynamics of small particles; shape and

size distribution; theory of sieving and grading of materials; packing; pressure; infiltration; capillarity.

(1349) A Survey of Powder Metallurgy Processes — II. L. A. Duran, *Rev. cienc. Applicada, 3,* No. 3, 168-85 (1949). Deals with the properties of powders, such as sizing and distribution, porosity, microstructure, surface finish, and capacity for flow.

A. Physical properties

(1350) Physical Properties of Nickel Tetracarbonyl. L. Mond and R. Nasini, *Z. physik. Chem., 8,* 150-57 (1891). Various physical properties of $Ni(CO)_4$ are discussed.

(1351) The Constitution of Metal Carbonyls. M. A. J. Ferreira Da Silva, *Bull. soc. chim., 15,* No. 3, 835-38 (1896). Ni and Fe carbonyls are investigated.

(1352) Physical Properties of Nickel Carbonyl. Sir J. Dewar and H. O. Jones, *Proc. Roy. Soc., A 71,* 427-38 (1903). The properties are investigated and discussed.

(1353) The Magnetization of Iron Powder. K. Honda, *Tohoku Imp. Univ., Sci. Rep., 6,* 139-47 (1917). The demagnetizing action due to the magnetized particles is very large, and therefore the magnetization of powder can only amount to a small fraction of that of compact mass of the same material, unless the magnetizing field is very strong; the demagnetizing factor is not constant but a function of the magnetic field, and of the density of the powder.

(1354) Determination of Electrical Resistance of Metallic Powders and Their Mixtures with Non-Conductors. O. Jäämaa and Y. E. G. Leinberg, *Soc. Sci. Fennica Commentationes Phys.-Math., 1,* No. 22, 20 pp. (1922); *Chem. Abstr., 17,* 1184 (1922). Electrical resistance of powders of Al, Zn, Ag, Cu, Fe, Sn, Sb, Ni, brass. Relation of electrical conductivity and pressure on powder.

(1355) The Binary Systems Na_2SiO_3-Na_2WO_4 and K_2SiO_3-K_2WO_4. J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 122,* 175-180 (1922). The melting points of the pure alkaline tungstates were determined.

(1356) Properties of Powders. The Variation of Pressure With Depth in Columns of Powder. J. C. Evans and J. H. Shaxby, *Trans. Faraday Soc., 19,* 60-70 (1923). Experiments on Pb shot; the absolute value of the pressure appears to be dependent on the state of packing of the column, and the resulting shape of the equal-pressure surfaces.

(1357) The Hardness of Electro-Deposited Iron, Nickel, Cobalt, Copper. D. J. Macnaughtan, *J. Iron Steel Inst. (London), 109,* 409-23 (1924). Brinell hardness numbers obtained by experimentation were: Cu 58-66, Fe 140-360, Ni 180-240, Co 270-311. Conditions of deposition have been found to cause an increase in hardness.

(1358) The Binary Systems Na_2WO_4-Li_2WO_4 and K_2WO_4-Li_2WO_4. J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 143,* 285-92 (1925). The melting points of mixtures of the pure alkaline tungstates were determined.

(1359) Conduction of Heat Through Powders, and Its Dependence on the Pressure and Conductivity of the Gaseous Phase. J. Aberdeen and T. H. Laby, *Proc. Roy. Soc. (London), A 113,* 459-77 (1926). A mathematical treatment is given.

(1360) Investigation on the Green Color of Tungstic Oxide. N. H. Smith and H. S. Lukens, *Chem. News, 132,* 33-35 (1926). The object of this investigation was to determine the extent of error produced by discoloration of the yellow WO_3.

(1361) The Green Color of Tungsten Oxide. J. A. M. Van Liempt, *Chem. News, 132,* 357 (1926). It is believed that the green color is a transition color between the pure yellow WO_3 and the blue W_2O_5.

(1362) A Few Properties of Powdered Tungsten Carbide (W_2C). K. Becker and R. Hölbling, *Z. angew. Chem., 40,* 512-13 (1927). Carbides prepared by heating at 1900° C. (3450° F.) of tungsten and carbon powders in carbonfree atmosphere..

(1363) Effect of Water on the Strength of Powdered Materials upon Heating. B. Garre, *Zement, 16,* 1023-24 (1927). Finely powdered Al_2O_3, SiO_2, and $CaCO_3$ with H_2O and C_6H_6 added, and heated to 900° C. (1650° F.), showed an increase in strength with the addition of H_2O, but a decrease with C_6H_6 due to surface action, distribution of particles and recrystallization.

(1364) Electrolytic Behavior of Thin Films. F. P. Bowden and E. K. Rideal, *Proc. Roy. Soc., A 120,* 59-79 (1928). Discussion of surfaces of irregularly shaped and finely divided bodies.

(1365) Iron Carbonyl and Carbonyl Iron. A. Mittasch, *Z. angew. Chem., 41,* 587-88, 827-33 (1928). Physical constants of iron carbonyl and carbonyl iron are given.

(1366) Reduction of Powdered Substances Weighed in Air and Vacuum – III. R. Ruer and J. Kuschmann, *Z. anorg. allgem. Chem., 173,* 233-61 (1928). The physical properties of the reduced Cu and Fe powders are described.

(1367) The Vapor Pressure of Nickel Carbonyl. J. S. Anderson, *J. Chem. Soc.,* 1653-6 (1930). The vapor pressure of $Ni(CO)_4$ is determined between -35 and 45° C. (-31 and 113° F.) by an equilibrium method. From the slope of the p-1/T curve, the molar heat of vaporization and the triple point are calculated.

(1368) Relation between Grain Composition and Space in Loose Granular Products and Experimental Results. A. H. M. Andreasen, *Ingeniören, 39,* No. 9, 99-107 (1930). Space can be kept constant with coarser grains if certain rules are followed. The Grum and Kerkhoft rules for obtaining densest compositions are compared.

(1369) The Bulking Properties of Microscopic Particles. P. S. Roller, *Ind. Eng. Chem., Ind. Ed., 22,* 1206-8 (1930). The bulkiness, or the volume per unit weight, was found to increase with the decrease in particle size below a critical diameter; for all powders the same functional relationship was found to hold between the voids per gram and the surface mean diameter.

(1370) Flow of Dry Sand Through Capillary Tubes. E. C. Bingham and R. W. Wikoff, *J. Rheol., 2,* 395-400 (1931). The effects of the length and the radius of the capillary are investigated.

(1371) X-Ray Investigation of Iron Tetracarbonyl. R. Brill, *Z. Krist., 77,* 36-42 (1931). $Fe(CO)_4$ is monoclinic prismatic, and the true molecule is $[Fe(CO)_4]_3$. The space group and unit cell dimensions are given.

(1372) Physical Characteristics of High Melting Compounds. K. Becker, *Physik. Z., 34,* No. 5, 185-98 (1933). Carbides of Ti, V, Zr, Cb, Ta, Hf, W, Mo. Nitrides of Ti, V, Zr, Cb, Ta and borides of W, Zr, Ti and V, all in powdered form, are considered.

(1373) Apparent Density, Tap Density and Sedimentation Volume as Measures of Fine-Size Products. H. W. Gonell, *Chem. Fabrik, 6,* 77-81 (1933). The relation between the different properties and the particle size is brought out.

(1374) Particle Size Distribution and Particle Sizes of Dustlike Materials. H. W. Gonell, *Chem. Fabrik, 6,* 227-33 (1933). A discourse on the dispersion of various powdered substances.

(1375) Optical Properties of Metallic and Crystalline Powders. A. H. Pfund, *J. Optical Soc. Am., 23,* 375-8 (1933). Method of preparing finely divided metal "blacks" is described, and the measurement on transparency in infrared is presented.

(1376) Laws Governing the Distribution of Grain Sizes in Cement. P. Rosin and E. Rammler, *Zement, 23,* 427-33 (1933). The relationship between particle size distribution and milling procedure is investigated.

(1377) Grain Size Problems in Sieving and Crushing. P. Rosin, E. Rammler, and K. Sperling, *Glückauf, 69,* 465-71 (1933). The effect of the milling procedure on particle size is investigated.

(1378) The Shape and Structure of Lead Shot. G. Tammann and K. L. Dreyer, *Z. Metallkunde, 25,* 64 (1933). The effect of As in permitting the formation of true spheres in Pb shot is one of fluxing the oxide formed. This flux surrounds the falling particle and forms it into a sphere.

(1379) Structure of Zinc Dust. G. Wassermann, *Metallwirtschaft, 12,* No. 1, 1-2 (1933). X-ray examination of Zn dust reveals zinc crystallites of about the same size as the particles recognizable under the microscope, so that each particle consists only of one or few crystals.

(1380) Powdered and Granulated Aluminum. *Metal Ind. (London), 44,* 350-353 (1934). Wear of aluminum paint and vehicles.

(1381) Covering Capacity of Aluminum Bronze Powder. J. D. Edwards and R. B. Mason, *Ind. Eng. Chem., Anal. Ed., 6,* 159-61 (1934). Capacity of powder to cover on water (wet) influences accuracy of particle size determination.

(1382) Evaluating Aluminum Bronze Powder. W. B. Roberts and J. D. Edwards, *Federation Paint & Varnish Clubs Off. Dig.,* No. 134, 61 (1934). Analysis of powder, mesh size, leafing power, color and brilliance, density, covering power, opacity and aluminum paste are discussed.

(1383) Molecular Structure of Nickel Carbonyl. L. O. Brockway and P. C. Cross, *J. Chem. Phys., 3,* 828-33 (1935). Electron diffraction by the vapor of $Ni(CO)_4$ indicates a molecular model in which the CO groups have a tetrahedral arrangement about the Ni atom with the distances Ni–C = 1.82 ± 0.03 A. and C–O = 1.15 A.

(1384) Thermochemical Investigations of Metal Hexacarbonyls. W. Hieber and E. Romberg, *Z. anorg. allgem. Chem., 221,* 332-6 (1935). The saturation pressures of $Cr(CO)_6$, $Mo(CO)_6$, and $W(CO)_6$ were determined, and their molecular heats of sublimation were calculated as 17.18, 16.29 and 17.71 kcal./mole, and their absolute boiling points at 760 mm. as 420.5, 429.4, and 448.0.

(1385) Crystal Structure of Chromium-, Molybdenum-, and Tungsten-Hexacarbonyl. W. Rüdorff and V. Hofmann, *Z. physik. Chem., B28,* 351-70 (1935). Experiments on these structures are described.

(1386) Particle Size Distribution in Several Milled Ceramic Materials. H. F. Vieweg, *J. Am. Ceramics Soc., 18,* 25-29 (1935). Specific size distributions are related to the type of material and to the milling conditions.

(1387) Abnormal Electrical Conductivity in Powdered Tellurium. C. H. Cartwright, *Phys. Rev., 49,* No. 6, 443-8 (1936). It was found that tellurium powder under pressure of 1000 kg./cm² had ten times greater specific electrical conductivity than that of a single crystal under the same pressure.

(1388) The Form of Technical Powders. R. Meldau, *Z. Ver. deut. Ing., Beiheft Verfahrenstechnik, No. 1,* 1-6 (1936). The form is shown to be dependent on the mechanical preparation.

(1389) Reducing the Space Occupied by Chemical Products by Shaking with a Shaking Machine. P. V. Nieth, *Farben-Ztg., 41,* 335 (1936). The volume of powders is reduced 30%.

(1390) Magnetic Properties of Colloidal Powders of Metallic Elements. S. R. Rao, *Current Science, 4,* 572-6 (1936). Investigation of magnetic properties of colloidal metals.

(1391) Heat Content and Lattice Distortions of Pyrophoric Iron. R. Fricke, O. Lohrmann and W. Wolf, *Z. physik. Chem., B37,* 60-74 (1937). An investigation is conducted on the activity of solid pulverulent matter, with special reference to lattice distortions, order of magnitude of particles, and the specific heat of pyrophoric iron powder.

(1392) Properties of Ferromagnetic Substances in Powder Form. O. Sappa, *Ricerca sci., 8,* Pt. II, 413-21 (1937); *Chem. Zentr., 109,* Pt. II, 269 (1938). Coercive force is found to be a function of the particle size.

(1393) Strength of Unfired Ceramic Bodies. H. v. Wartenberg, *Z. angew. Chem., 50,* 734-7 (1937). Experiments on SiO_2, $BaSO_4$, $CaCO_3$ and $BaCrO_4$ powders to determine the surface tension of dry and moistened ceramic bodies are described.

(1394) Colloidal Fractions of Milled Products. A. H. M. Andreasen, *Ber. deut. keram. Ges., 19,* 23-29 (1938). A discourse on the particle size distribution and the proportion of superfines as related to the material and the milling procedure.

(1395) Electron-Diffraction Investigation of the Hexacarbonyls of Chromium, Molybdenum, and Tungsten. L. O. Brockway, R. V. G. Ewens, and M. W. Lister, *Trans. Faraday Soc., 34,* 1350-7 (1938). Electron diffraction by the vapors shows that these 3 molecules are regular octahedral with the metal at the center and the 6 CO groups directed to the apexes. The bonding and atomic distances are discussed and compared with previous results.

(1396) The Size and Surface of Fine Powders. P. C. Carman, *J. Chem. Met. Min. Soc. S. Africa, 39,* 266-81 (1938). Experiments on Zn dust are reported.

(1397) Physicochemical Nature of Metallic Interfaces. R. S. Dean, *U. S. Bureau of Mines, Rept. of Invest.*, No. 3400, 3-20 (1938). The behavior of powdered metallic substances in high-frequency electric circuits is investigated.

(1398) Heat Content of Gold. R. Fricke and F. R. Meyer, *Z. physik. Chem., A181,* 409-29 (1938). In an investigation of the activity of solid, pulverulent matter, a study is made of the specific heat as a function of the degree of dispersion of gold.

(1399) Heat Content and Lattice Condition of Active Copper. R. Fricke and F. R. Meyer, *Z. physik. Chem., A183,* 177-89 (1938). In the course of an investigation on the activity of solid, pulverulent matter, the specific heat and lattice condition of pyrophoric copper powder is studied.

(1400) Crushing and Grinding. J. Gross, *U. S. Bur. Mines Bull.*, No. 402 (1938). Theoretical and practical discussion of specific surface of powders.

(1401) The Amorphous State of Metals. A. Schulze, *Metallwirtschaft, 17,* 1243-48 (1938). This condition is obtained by evaporation, cathodic dispersion or electrolysis at very low temperatures. Also, polished or abraded surface of ordinary crystalline metals may be amorphous. At specific temperatures, the metals are transformed into their common, crystalline state, *e. g.*, Al at -133° C. (-207° F.), Fe at + 167° C. (+333° F.), Ni at +63° C. (+145° F.) and Zn at -140° C. (-220° F.).

(1402) Effect of Particle Shape of White Pigments on Opacity. H. A. Depew and A. C. Eide, *Ind. & Eng. Chem., Anal. Ed., 32,* No. 4, 537-40 (1940). The optical properties of acicular particles are determined by the cross-sectional diameter of the needles, which act toward light as if they were cut off into tiny rounds of the optimum size.

(1403) Lattice Formation of Active Nickel. R. Fricke and W. Schweckendiek, *Z. Elektrochem., 46,* 90-95 (1940). In the course of an investigation on the activity of solid, pulverulent matter, the specific heat and lattice conditions of active nickel are studied.

(1404) Anisotropy of Ferromagnetic Powder Particles. E. T. Benedikt, *J. Applied Phys., 13,* 105-9 (1942). Measurement of the magnetic moment of sediments of ferromagnetic particles show that the particles are magnetically anisotropic. The dependence on the magnetic field is investigated.

(1405) Structure of Mixed Crystals. L. Graf, *Z. Elektrochem., 48,* 184-210 (1942). The lamellae-type structure of the interior and line-type structure of the surface of particles is described.

(1406) Powder Production and Classification. D. O. Noel, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 8, pp. 109-123. Structure, particle size, density and flow are discussed.

(1407) Density of Metal Powder Particles. *Iron Age, 154,* No. 11, 57 (1944). The apparent, average particle and solid density of electrolytic and reduced iron, electrolytic copper and atomized lead are compared and comments are made on the significance of each specific property.

(1408) British Electrolytic Copper Powder. H. W. Greenwood, *Metallurgia, 30,* No. 178, 181-84 (1944). The flow factor and other physical properties in the powder are discussed.

(1409) The Form of Particles of Nickel Produced by Carbonyl Process. F. W. Cuckow, *J. Roy. Microscopical Soc., 65,* Ser. 3, 23-28 (1945). Electron microscopical examination of nickel powders has revealed two types of powder consisting of: *(1)* mixture of irregularly shaped and cube shaped particles, and *(2)* characteristically shaped particles with smooth surfaces.

(1410) Electric Contacts between Metallic Bodies. J. Frenkel, *J. Physics (U. S. S. R.), 9,* No. 6, 489-93 (1945) (in English). Fine metallic powders and thin films show an increase of conductivity with temperature according to a law analogous to that controlling the conductivity of semiconductors.

(1411) Principles of Powder Metallurgy. R. Girschig, *Rev. Mét., 42,* 178-186 (1945). The structure of carbonyl iron powder particles is investigated, and primary crystallites of a size of 10^{-3} microns diameter are found.

(1412) Magnetic Method for Testing Diffusion in Metal Powders. P. W. Selwood and J. Nash, *Trans. Am. Soc. Metals, 35,* 609-615 (1945). 300 mesh mixed powders of pure copper and nickel of several concentrations were tested magnetically at temperatures from 30-400° C. Repeat measurements after one week's heating. The approach to homogenity is indicated by an irregular lowering of the Curie point.

(1413) Photoelectric Properties of Metals in the Finely Divided State. L. J. Reimert, *J. Opt. Soc. Am., 36,* No. 5, 278-83 (1946). Cadmium, antimony, and zinc were tested.

(1414) Revue of Work of Kaiser Wilhelm Institut on Powder Metallurgy of Iron. H. Wiemer, U. S. Dept. Comm. PB. 14760, 1946, 11 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 19, 1108 (1946). Physical and mechanical properties of the powders are shown to be dependent upon their structure.

(1415) Manufacture and Uses of Iron Powders. F. Eisenkolb, *Arch. Metallkunde, 1,* No. 7/8, 327-334 (1947). An analysis of the physical characteristics is presented.

(1416) Superconductivity and Structures of Hydrides and Nitrides of Tantalum and Columbium. F. H. Horn and W. T. Ziegler, *J. Am. Ceram. Soc., 69,* No. 11, 2762-68 (1947). Temperature below which superconductivity occurs varies inversely with dimension of the lattice parameters, *i. e.*, with hydrogen and nitrogen content in a series of hydrides or nitrides. Tantalum and columbium used as granular powders.

(1417) Some Factors Affecting Particle Size of Hydrogen-Reduced Tungsten Powder. B. Kopelman, *Trans. Am. Inst. Mining Met. Engrs., 171,* 457-472 (1947). Review of literature; reduction experiments; analysis and correlation of data; volatilization temperatures and kinetics of reaction process. Discussion.

(1418) Crystalline Aggregation of Cobalt Powder. J. T. McCartney, *J. Applied Phys., 15,* No. 10, 902-3 (1947). An interesting phenomen observed in electron microscope studies in Co powder reduced from Co oxide; the oxide particles sintered into larger smooth droplets of Co, that were aggregated into thin hexagonal-shaped platelets.

(1419) Heat of Combustion of Tungsten Carbide Powder. L. D. McGraw, H. Seltz and P. Snyder, *J. Am. Chem. Soc., 69,* 329-333 (1947). Determined in a precision calorimeter and heat of formation calculated from the results.

(1420) Flake Metal Powders — Their Application, Manufacture, and Testing Methods. H. Meyersberg, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, *London,* 1947, pp. 37-46; *Met. Powd. Rept., 1,* No. 11, 162-163 (1947). The physical properties of flake and granular metal powders are compared. The powders are used in the paint industry, in making lightweight concrete, and in pyrotechnics. A short account is given of the methods used in testing flake powders.

(1421) Nature, Properties, and Applications of Carbonyl-Iron Powder. L. B. Pfeil, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 47-51. It is shown that iron powder made by the carbonyl process possesses outstanding electromagnetic properties, which are associated with the spherical form, fine particle size, and structure of the powder.

(1422) Structure of Uranium Hydride and Deuteride. R. E. Rundle, *J. Am. Chem. Soc., 69,* No. 7, 1719-23 (1947). Debye-Scherrer powder diagrams of uranium hydride show that there are 8 uranium atoms and 24 hydrogen atoms per unit. U-metal has been heated with U-hydride and two phases are maintained. Uranium deuteride is uranium compound with heavy hydrogen (UD_3).

(1423) Widia Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3779/47 (1947). Results of X-ray tests on 19 Widia powders were reported in 1938.

(1424) Densities of Tungsten Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3872/47 (1947). Tungsten powders have apparent densities which cannot be correlated either with the raw material or the cutting quality of the tool. Further investigations are suggested in this report of 1941.

(1425) Grain Size of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3891/47 (1947). X-ray investigations in 1941 show that tungsten with a size of 10 microns is carburized to tungsten carbide with a grain size of 1 micron. Tungsten from para-salts gives a coarser grained carbide than tungsten from tungstic acid.

(1426) Particle Hardness of Iron Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3975/47 (1947). Connections between the manufacturing method and the particle hardness of iron powders are described in this report of 1945.

(1427) Particle Surface Properties of Tungsten and Tungsten Carbide Powders. *Met. Powd. Rept., 2,* No. 9, 132 (1948). Ref. to *Studienges. Hartmetall,* April 1941; B.O.T. Germ. Div. F.D. 3881/47. A number of tungsten powders of different origin but similar particle size were pressed and sintered; shrinkages range from 3.0-23.6% at 1700° C. (3090° F.).

(1428) Microwave Magnetic Dispersion in Carbonyl Iron Powder. J. B. Birks, *Phys. Rev., 74,* Ser. 2, No. 7, 843-44 (1948). Typical results for the modulus of permeability and the magnetic loss angle of a specimen containing 18% iron powder are given. The magnetic dispersion and absorption of iron does not display any of the resonance characteristics attributable to internal fields of anisotropy that are observed in iron oxides.

(1429) Magnetic Properties of Iron Powder. G. F. Hüttig and H. Rainer, *Powd. Met. Bull., 3,* No. 3, 48-60 (1948). The magnetic properties of iron powder are affected by changes in the surface conditions of the particles. Introduction with a historical review; discussion.

(1430) The Heat of Formation of Tungstic Oxide. G. Huff, E. Squitieri, and P. E. Snyder, *J. Am. Chem. Soc., 70,* 3380-81 (1948). The heat of formation of WO_3 was redetermined, was found to be -200.16 kcal. per mole., and was used for the calculation of the heat of formation of WC.

(1431) Factors Governing Particle Size of Powders. R. North, *Ind. Chemist & Chem. Manufacture, 24,* No. 1, 5-11 (1948). Results obtained by different techniques. The observations and data for the curves are based on the experience gained with commercial installations in the Testing Dept. of Grinding Division of International Combustion Ltd.

(1432) Changes in Magnetic Properties of Iron Powder through Surface Modifications. H. Rainer, *Met. Powd. Rept., 2,* No. 12, 190 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 196 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 24. An electrolytic iron powder and a carbonyl iron powder were treated in different ways. The induced magnetism of the electrolytic iron powder was lower after treatment, with one exception. The same applied to carbonyl powders which showed higher values at low field strength than the original powder.

(1433) A New Interpretation of Interstitial Compounds — Metallic Carbides, Nitrides and Oxides of Composition MX. R. E. Rundle, *Acta Cryst., 1,* 180-7 (1948). The following compounds have the NaCl crystal-structure type: ThC, ThN, ThO, UC, UN, UO. The concept of half-bonds is used for the explanation of physical properties of interstitial phases with the NaCl type structure.

(1434) Some Characteristics of Sprayed Metals. C. Tolley, *Metallurgia, 38,* 263-264 (1948). Sprayed metal is distinguished by its lamellar structure; upon hitting the surface of the object the spray particles are flattened out into a saucer shape, partly through the impact and partly through tension forces. No crystal growth or sintering is involved in the formation of a sprayed deposit.

(1435) Heat Capacity of Beryllium Carbide Powder. J. B. Trice, J. J. Neely, and C. E. Teeter, Jr. *Fairchild Engine and Airplane Corp. Rept.*, 1948, 14 pp.; *Nuclear Sci. Abs., 2,* 12 (1949). A thin capsule containing a sample was heated in an electric furnace and dropped into a water calorimeter.

(1436) Special Properties of Ultrafine Ferromagnetic Powders. L. Weil, *Met. Powd. Rept., 2,* No. 12, 189 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 195 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 17. According to Néel's theory, when a particle represents a complete domain, magnetization is oriented by the direction of the longest axis of particle, and also by the direction of the easiest magnetization, *e. g.*, along the edge of the particle in the case of iron.

(1437) Thermal Variations in Coercive Field of Finely Divided Cobalt. L. Weil, S. Marfoure and F. Bertaut, *J. phys. radium, 9,* Ser. 8, 203-7 (1948). Hexagonal particles of Co have a minimum coercive field at 200° C., four times smaller than in liquid air.

(1438) Investigations into the Significance of Apparent Density as a Characteristic of Properties of Metal Powders. H. Bernstorff and F. Moser, *Arch. Metallkunde, 3,* 317-23 (1949). Three German iron powders were tested for variation of apparent density in seven size fractions. The scattering decreased with the finer fractions so that powders with higher percentage of fines gave better uniformity in pressing.

(1439) Relation Between Manufacturing Process of Iron Powders and Crystal Hardness. W. Dawihl and U. Schmidt, *Z. Metallkunde, 40,* No. 3, 117-9 (1949). A chart shows how microhardness of sintered iron particles is increased by high pressing loads.

(1440) The Volatility of Molybdic Acid. T. Dupuis, *Compt. rend., 228,* 841-43 (1949). The weight curves obtained on heating NH_4 para-molybdate in a thermobalance from 0 to 900° C. indicate that MoO_3 does not start to volatilize below 782° C. With heterocomplex molybdates, such as NH_4 phosphomolybdates, the MoO_3 does not evolve below 800° C.

(1441) Coercive Field of Ferromagnetic Powders. C. Guillaud, *Compt. rend., 229,* No. 17, 818-9 (1949). Study carried out on Mn_2Sb alloy to confirm author's conclusions that very finely powdered ferromagnetic substances can present magnetic properties very different from those observed on the same metals or alloys in solid form.

(1442) Some Ferromagnetic Properties of Mixed Ferrites of Nickel and Zinc. C. Guillaud and M. Roux, *Compt. rend., 229,* 1133-35 (1949). Two graphs indicate the changes in magnetic saturation and in Curie point with the percentage of NiO in the powder, while the third graph contains curves of spontaneous magnetization as a function of temperature.

(1443) Volatility of Oxides of Tungsten and Molybdenum in Presence of Water Vapor. T. Millner and J. Neugebauer, *Nature, 163,* 601-2 (1949). Experimental results quoted show that the sublimation of various tungsten oxides is promoted considerably by water vapor. In hydrogen reduction of WO_3 the increased particle size is not due to the inherent volatility of trioxide.

(1444) Influence of Thermal Fluctuations on Magnetization of Very Fine Ferromagnetic Particles. L. Néel, *Compt. rend., 228,* 664-66 (1949). A mathematical equation is given.

(1445) Ferrite Materials. D. Polder, *Symposium on Ferromagnetic Materials,* Institution of Electrical Engineers, Nov. 7-8, 1949; *Met. Powd. Rept., 4,* No. 4, 59 (1949). The changes with frequency of retentivity, permittivity, and residual losses are demonstrated in manganese-zinc and nickel-zinc ferrites. The molecular structure of ferrites and methods of measurement are discussed.

(1446) Effect of a Pencil of Intense Light Rays on Metal Particles Falling in Air at Different Pressures. P. Tauzin, *Compt. rend., 228,* 1284-86 (1949). Experiments are made with Fe, Ni, Co, Mo, W powders. At atmospheric pressure and with light of given intensity, the powders are attracted or repelled during their fall, depending on the particle size.

(1447) Coercive Field and Particle Size Distribution of Raney Nickel. L. Weil, *Compt. rend., 229,* 584-5 (1949). In contrast to Ni powder made by reduction of oxalate or formate, Raney nickel gives increasing coercivity values after pressing and again after sintering.

(1448) Magnetic Domain Patterns on Single Crystals of Silicon-Iron. H. J. Williams, R. M. Bozorth and W. Shockley, *Phys. Rev., 75,* 155-78 (1949). The relatively simple structure of the internal domains of magnetic powder patterns was revealed by means of colloidal suspension of Fe_3O_4.

(1449) Nature of Metal Powder Prepared by Reduction of Oxides. B. Kopelman, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, Chap. 18, pp. 303-310 (1951). The structure of reduced tungsten powder is discussed. The pycnometrically determined density of the powder varies with temperature and time of reduction; this is caused by the effects of pore shrinkage due to sintering and pore expansion due to entrapped water vapor.

B. Chemical Properties

(1450) Nickel Carbonyl. M. Berthelot, *Compt. rend., 113,* 679-80 (1892). The oxidation of nickel carbonyl is described.

(1451) Researches on Tungsten and other Refractory Metals and Carbides. H. Moissan, *Compt. rend., 123,* 13-16 (1896). Solubility of C in tungsten, rhodium, iridium, palladium powders is described.

(1452) Influence of Carbon on Platinum and Palladium. E. Harbeck and G. Lunge, *Z. anorg. Chem., 16,* 50-66 (1898). The reaction between Pt or Pd and carbon (in powder form) is investigated.

(1453) Ammonium Tungstates. T. M. Taylor, *J. Am. Chem. Soc., 24,* 629-43 (1902). It is reported that solutions of tungstic acid in ammonia are unstable.

(1454) Physical and Chemical Properties of Iron Carbonyl. Sir J. Dewar and H. O. Jones, *Proc. Roy. Soc., A76,* 558 (1905). The photochemical equilibrium between $Fe(CO)_5$ and $Fe_2(CO)_9$ in solvents other than $Ni(CO)_4$.

(1455) On a New Iron Carbonyl and on the Action of Light and of Heat on the Iron Carbonyls. Sir J. Dewar and H. O. Jones, *Chem. News, 95,* 97, 109 (1907). It was shown in an earlier paper, [*Proc. Roy. Soc., A76,* 558, (1905)] that the action of light on iron pentacarbonyl alone or in solution in solvents, with the exception of nickel carbonyl, is represented by the equation $2\ Fe(CO)_5 = Fe_2(CO)_9 + CO$.

(1456) Iron Carbonyls. Sir J. Dewar and H. O. Jones, *Chem. News, 96,* No. 87, 75 (1907). Iron pentacarbonyl, $Fe(CO)_5$, is a yellow liquid resembling nickel carbonyls but is more stable towards chemical reagents. Unlike nickel carbonyl, iron pentacarbonyl is decomposed by light, giving rise to carbon monoxide and orange, crystalline diferro-nonacarbonyl, $Fe_2(CO)_9$.

(1457) A New Iron Carbonyl. Sir J. Dewar and H. O. Jones, *Proc. Roy. Soc., A79,* 66-79 (1907). Experiments on the action of light on liquid iron carbonyl are described.

(1458) Interaction of Nickel Carbonyl and Carbon Disulfide. Sir J. Dewar and H. O. Jones, *J. Chem. Soc., 97,* 1226-30 (1910). The conditions affecting the reaction are discussed.

(1459) The Cause and Prevention of Aluminum Dust Explosions. R. J. Zink, *Chem. Ztg., 35,* 1370-2 (1911). A discourse on the subject is given.

(1460) Effect of Sodium Chloride on Blue Zinc Powder Formation. R. S. Dean, *Chem. & Met. Eng., 20,* 628 (1919). The formation of blue powder is due to the reoxidation of zinc by carbon dioxide existing in the condenser. The percentage of carbon dioxide in equilibrium with a given mixture is greater at high than at low temperatures.

(1461) Reaction of Water on Tungsten and W Oxides. C. Chaudron, *Compt. rend., 170,* 1056-58 (1920). The chemical equilibrium conditions are investigated between tungsten oxides, hydrogen and water vapor in the reduction process for tungsten powder.

(1462) Types of Valence. I. Langmuir, *Science, N. S., 54,* 59-67 (1921). The compounds $Fe(CO)_5$ and $Ni(CO)_4$ correspond to complete compounds in which the central atoms have the covalences 10 and 8, respectively.

(1463) The Equilibrium of Tungsten and Tungsten Oxides with Hydrogen and Carbon. J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 120,* 267-75 (1922). The chemical equilibrium conditions between W, W oxides, H_2, C, and water vapor are investigated in the reduction process for tungsten powder.

(1464) Some Derivatives and Reactions of Iron Pentacarbonyl. H. Freundlich and E. J. Cuy, *Ber., 56B,* 2264-7 (1923). The statements of Dewar and Jones were, in general, confirmed.

(1465) Preparation of WO_2 and W_2O_5. J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 126,* 183-184 (1923). The equilibrium conditions between tungsten oxides and hydrogen, water vapor, etc. in the production of tungsten powder are discussed.

(1466) On the Reactivity of Solid Phases. J. A. Hedvall, *J. physik. Chem., 28,* No. 2, 1316-30 (1924). Study of reactions of powder mixtures of oxides, etc.

(1467) On the Pyrophoric Properties of Metallic Dusts. F. Sauerwald, *Metall u. Erz, 21,* 117-20 (1924). Pyrophoric material obtained by hydrogen reduction of metal oxides at lowest possible temperatures. Higher temperature yields non-pyrophoric material.

(1468) On the Pyrophoric Properties of Metal Powders. G. Tammann and N. J. Nikitin, *Z. anorg. allgem. Chem., 135,* 201-4 (1924). Certain metal powders ignite after their oxides are reduced by hydrogen at low temperatures. Tests made on Ni and Ti for different low temperatures of reduction (370-660° C.; 700-1220° F.).

(1469) Passivity of Zinc Dust. B. A. Izmailskii and B. I. Kolpenskii, *J. Chem. Ind. (U. S. S. R.), 1,* 131-2 (1925). Chemical behavior of zinc dust employed in reduction of nitro-compounds in alkaline solution.

(1470) The Constitution of Nickel Carbonyl. A. A. Blanchard and W. L. Gilliland, *J. Am. Chem. Soc., 48,* 872-82 (1926). The reactions of $Ni(CO)_4$ with Br, S, O, and Grignard reagents are described and indicate that it is a loose association of Ni and CO, either constituent reacting alone with substances with which it would be expected to react were it in the free state, leaving the other constituent uncombined. The authors propose a structure of carbonyls which would account for the extreme volatility of these compounds.

(1471) Nickel Carbonyl Carbon Monoxide and Grignard Reagents. W. L. Gilliland and A. A. Blanchard, *J. Am. Chem. Soc., 48,* 410-20 (1926). CO has been made reactive with Grignard reagents but only as a constituent of $Ni(CO)_4$; the $Ni(CO)_4$ is, however, continuously regenerated from the liberated Ni and fresh CO.

(1472) Vanadium, Titanium and Hydrogen. H. Huber, L. Kirschfeld and A. Sieverts, *Ber., 59,* 2891-2896 (1926). An investigation is made of the solubility of the gas in the metals, and the effect of the specific surface is shown.

(1473) Passivity of Zinc Dust. B. Ismailskii and B. Kolpenskii, *Z. angew. Chem., 39,* 507-9 (1926). Abstract from *J. Chem. Ind. (U. S. S. R.), 1,* 131-2 (1925).

(1474) Precautions in Working with Low Temperature Baths. A. Mittasch and E. Kuss, *Chem.-Ztg., 50,* 125 (1926). Disastrous explosions are cited from cooling nickel carbonyl with liquid air, probably due to leaks in the container which allowed liquid air to reach the condensate. Liquid N_2 is preferable to liquid air as coolant.

(1475) Adsorption of Gases by Finely Disintegrated Metals. N. J. Nikitin and V. I. Sharkov, *J. Phys. Chem. Soc. (U. S. S. R.), 58,* 1095-1100 (1926). Adsorption of H_2, CO_2 and NH_3 by Cu, Pb, Fe, Co, Ni, $NiAl_2O_3$ mixture and Ag.

(1476) Reduction of Powdered Substances Weighed in Air and Vacuum – I. R. Ruer and J. Kuschmann, *Z. anorg. allgem. Chem., 154,* 69-78 (1926). Adsorption of gases on metallic surfaces, *e. g.,* Fe and Cu powders is described.

(1477) Zirconium, Thorium and Hydrogen. A. Sieverts and E. Roell, *Z. anorg. allgem. Chem., 153,* 289-308 (1926). The solubility relationships are investigated with particular reference to the specific surface.

(1478) Heating Powdered Substances Below Their Melting Points and Eutectic Temperatures. B. Garre, *Zement, 17,* 446-48 (1928). The reactivity of powdered solids on heating below their melting points or eutectic temperatures is aided by compacting into pellets or by mixing with liquids, especially those liquids in which one or both solids are soluble.

(1479) Titanium and Hydrogen. L. Kirschfeld and A. Sieverts, *Z. physik. Chem., A145,* 227-40 (1929). Reactions between the gas and metal are treated, and special reference is made to the metal in powder form.

(1480) Sorption of Gases by Metals. A. Sieverts, *Z. Metallkunde, 21,* 37-46 (1929). Reference is made to the solid, pulverulent state of the metals and its high degree of susceptibility to gas sorption, and solubility for oxygen, nitrogen and hydrogen.

(1481) Germanium, Indium, Columbium, Titanium and Hydrogen. H. Hagen and A. Sieverts, *Z. anorg. allgem. Chem., 185,* 225-238 (1930). The relations and reactions between hydrogen and the different rare metals are treated and special reference is made to the specific surface of the metals when in powder form.

(1482) Reactivity of Powdered Metals. A. Haid, H. Goetze, H. Selle, H. Koenen, A. Schmidt and F. Becker, *Jahresber. chem. techn. Reichsanstalt, Abt. Sprengstoffe, 8,* 136-41 (1930). Reactivity of powders related to dispersion. Metal powders must have a very large surface to be ignited at low temperature. The temperature of inflammation increases with the grain size.

(1483) Spontaneous Inflammability of Magnesium Powder. F. Lenze, L. Metz and E. Rubens, *Jahresber. chem. tech. Reichsanstalt, Abt. Sprengstoffe, 8,* 12-14 (1930). Causes, and means of protection, especially during manufacture.

(1484) Causes of Ignition of Al Dust During Manufacture. F. Ritter, *Z. Ver. deut. Ing., 74,* 145-8 (1930). Review.

(1485) The Adsorption of Nitrogen by Iron. A. Sieverts, *Z. physik. Chem., A155,* 299-313 (1931). The solubility of N_2 in Fe between 700 and 1130° C. (1290 and 2060° F.) is measured.

(1486) Carbon-Oxygen Linkage in Metal Carbonyls. J. S. Anderson, *Nature, 130,* 1002 (1932). The Raman effect affords decisive evidence that carbon monoxide is present in metal carbonyls.

(1487) A Dark Blue Nickel Oxide. M. Centnerszwer and H. Zyokowicz, *Z. anorg. allgem. Chem., 206,* 252-6 (1932). Influence of NO on Ni. NO does not influence sheet of Ni, but produces a blue color on Ni powder.

(1488) J. W. McBain, *The Sorption of Gases and Vapours by Solids.* G. Routledge, London, 1932, 577 pp. The comprehensive treatment of the interaction between common gases and industrial metals includes the latter in comminuted state.

(1489) Venting Dust Explosions. R. Brown and H. Hanson, *Quart. Natl. Fire Protect. Assoc., 26,* 328-41 (1933). Simple rules have been formulated to reduce the hazards of explosions and fires connected with metal powders.

(1490) Spontaneous Ignition of Metals. T. Freitag, *Z. Oberflächentechnik, 10,* 130-2 (1933). Refers mainly to Mg alloys, includes reference to powders.

(1491) Sorptive Capacity of Molybdenum-Iron Alloys for Hydrogen and Nitrogen. A. Sieverts and H. Brüning, *Arch. Eisenhüttenw., 7,* 641-45 (1933/34). The test samples were made from molybdenum powder and wire. The variation of the sorptive capacity is in conformity with the constitution diagram for the system Fe-Mo.

(1492) Apparatus for the Grinding of Copper in High Vacuum and the Adsorption of Gases by the Resulting Powder. F. Durau and H. Franssen, *Z. Physik, 89,* 757-73 (1934). Sorptive behavior of powders in experiments with hydrogen, nitrogen, oxygen, carbon oxides and hydrocarbons described.

(1493) Thermal Decomposition and Oxidation of Nickel Carbonyl. A. P. Garratt and H. W. Thompson, *J. Chem. Soc.*, 1822-5 (1934). The reaction between nickel carbonyl and oxygen and the thermal decomposition of the carbonyl over the temperature range 0-100° C. (32-212° F.) was studied.

(1494) Absorptive Capacity of Cobalt for Hydrogen and Nitrogen. A. Sieverts and H. Hagen, *Z. physik. Chem., A169,* 237-240 (1934). The solubility of H_2 and N_2 in Co between 600 and 1200° C. (1110 and 2190° F.) is measured.

(1495) Vapor Pressure and Molecular Weight of Chromium Carbonyl. M. M. Windsor and A. A. Blanchard, *J. Am. Chem. Soc., 56,* 823-5 (1934). The vapor pressure of $Cr(CO)_6$ from room temperature to 125° C. (257° F.) is given by the equation $\log p = 10.63 - (3285/T)$. $Cr(CO)_6$ decomposes slightly at 100° C. (212° F.) and very rapidly at 135° C. (275° F.). This reference is of significance for the production of chromium metal powder from the carbonyl.

(1496) Kinetics of the Decomposition of Nickel Carbonyl. C. E. H. Bawn, *Trans. Faraday Soc., 31,* 440-6 (1935). The decomposition of $Ni(CO)_4$ in Ni-coated vessels according to the equation $Ni(CO)_4 \rightleftharpoons Ni + 4CO$ was investigated at temperatures from 100 to 128° C. (212 to 262° F.).

(1497) Study of Finely Divided Metals and a Method for Their Preparation. E. G. Insley, *J. Phys. Chem., 39,* 623-36 (1935). Adsorption of hydrogen, C_2H_4, C_2H_6 and other gases on particle surfaces is investigated.

(1498) Iron and Nitrogen. A. Sieverts and G. Zapf, *Z. physik. Chem., A172,* 314-15 (1935). Measurement of the solubility of N_2 in Fe above 1200° C. (2190° F.).

(1499) Solubility of Deuterium and Hydrogen in Palladium. A. Sieverts and G. Zapf, *Z. physik. Chem., A174,* 359-64 (1935). The solubility of H_2 and D_2 in Pd between 300 and 1100° C. (570 and 2010° F.) is measured.

(1500) Influence of Nitrogen on Nickel Carbonyl. J. S. Anderson, *Z. anorg. allgem. Chem., 229,* 357-68 (1936). The reaction between Ni-carbonyl and nitrogen is investigated and described.

(1501) Measurement of Pressure during the Explosion of Aluminum Dust. W. Glitwitzky, *Z. Ver. deut. Ing., 80,* 687-92 (1936). Discussion of the hazards of handling powders of the light metal group.

(1502) Effect of Pressure on the Passivity of Iron Powder in Alkali Medium. T. C. Huang, *Chinese Chem. Soc., 4,* 406-412 (1936). The measurement of discharge potential at definite intervals shows that an increase of the packing pressure increases the electromotive activity and decreases the passivity of Fe powder.

(1503) Extinguishers for Zinc Dust Fires. S. H. Katz and J. J. Bloomfield, *Week. Underwr., 134,* 247-8 (1936). Small lots of dust were heated in a ladle over a forge until ignited; the burning dust was dumped in a heap on an asbestos board, and the effect observed when water, sodium bicarbonate, CCl_4 or Si tetrachloride were applied.

(1504) Molybdenum and Nitrogen. A. Sieverts and G. Zapf, *Z. anorg. allgem. Chem., 229,* 161-74 (1936). The gas-metal reactions are treated on the basis of experimental results; the effect of specific surface, especially in the case of the metal in powder form, is shown.

(1505) Solubility of Deuterium and Hydrogen in Palladium. A. Sieverts and G. Zapf, *Z. physik. Chem., B34,* 158-59 (1936). The solubility of H_2 and D_2 in Pd between 300 and 1100° C. (570 and 2010° F.) is measured.

(1506) Kinetics of the Oxidation of Metallic Spheres and Powders. G. Valensi, *Compt. rend., 202,* 309-12, 414-16 (1936). Ni powder used in the investigation.

(1507) Chemical Fire Extinguishing Danger in Aluminum Powder. C. B. White, *Safety Engr., 71,* 31 (1936). General discussion of the subject.

(1508) Fuel Research. C. M. Cawley and J. G. King, *Dept. Sci. Ind. Research (Brit.),* Tech. Paper No. 45, 1937. No change in catalytic activity of molybdenum oxide pellets was observed from - 1/4 + 1/8 in. mesh to - 1/8 + 1/16 in. mesh.

(1509) Fire Hazard of Iron Carbonyl in Light-Oil Plant. H. Fischer, *Glückauf, 73,* 717 (1937). Iron carbonyl in wash oil is the primary substance which under certain conditions of temperature dissociates to form molecularly dispersed iron. Access to air produces a fog of iron oxide and spontaneous ignition.

(1510) Explosion of Aluminum Powder Dust Clouds. R. B. Mason and C. S. Taylor, *Ind. Eng. Chem., Ind. Ed., 29,* 626-627 (1937). Two lots of Al powder are employed; the 0.14 micron powder has excellent dispersion and suspension properties. A novel igniter for the use in experimental explosion chambers was devised in the course of this work.

(1511) Manganese and Hydrogen. A. Sieverts and H. Moritz, *Z. physik. Chem., A 180,* 249-63 (1937). The solubility of H in Mn is measured.

(1512) Solubility of Deuterium and Hydrogen in Palladium. A. Sieverts and G. Zapf, *Z. physik. Chem., B38,* 4646-60 (1937). The solubility of H_2 and D_2 in Pd between 300 and 1100° C. (570 and 2010° F.) is measured.

(1513) Extremely High Solubility of Nitrogen and Oxygen in Several Metals. J. D. Fast, *Metallwirtschaft, 17,* 641-44 (1938). Studies on zirconium and titanium are described.

(1514) J. A. Hedvall, *Die Reaktionsfähigkeit fester Stoffe.* Barth, Leipzig, 1938, 234 pp. The constitution of solids is treated, and an account is given of an investigation of the reactivity of solid matter in the pulverulent state, for which experimental results are given.

(1515) Properties and Treatment of Powder Produced in Zinc-Distillation Furnaces. N. A. Popov and N. A. Nikolaev, *Tsvetnye Metal., 13,* No. 6, 65-73 (1938) (in Russian); *Chemie & Industrie, 41,* 693 (1938). Zn powder contains impurities, *e. g.,* Pb, Fe and ZnO.

(1516) Solubility of Hydrogen, Deuterium and Nitrogen in Iron. A. Sieverts, G. Zapf and H. Moritz, *Z. physik. Chem., A183,* 19-37 (1938). The solubility relationships between iron and H_2, D_2 and N_2 are investigated.

(1517) Quality of Metal from Steeproch Lake Iron Ore. O. W. Ellis, *Can. Chem. Process Ind., 23,* 353-54 (1939). Sponge iron by charcoal contains 93.3% Fe, 3.9% SiO_2.

(1518) J. K. Roberts, *Some Problems in Adsorption.* Cambridge University Press, Cambridge, 1939, 119 pp. On page 109 it is stated that there is a possibility that a certain minimum temperature is required to remove the adsorbed gas films held to powder particles by van der Waals' forces.

(1519) Relation between Catalytic Activity and Size of the Particle. E. A. Thiele, *Ind. Eng. Chem., Anal. Ed., 31,* 916-20 (1939). A mathematical treatment of the subject is given.

(1520) Activity of Zinc Dust. B. Vakhmistrov, *Tsvetnye Metal., 14,* No. 10-11, 135-6 (1939). Chemical behavior in catalytic reactions. Activity of Zn, with ZnO not over 10%, depends on the particle size, increasing with decrease in size.

(1521) Zinc Dust. *Chem. Fabrik, 13,* 362 (1940). A description of spontaneously combustible zinc-dust residues as cause of fires.

(1522) Research on Burning and Explosion of Light Metals. H. Berger, *Metallwirtschaft, 19,* No. 20, 404-11 (1940). Al powder explodes with water; Al bronze is dangerous in powder form. The finer the particle size the greater the affinity for oxygen. References.

(1523) Explosibility of Aluminum Powder-Silica Dust Clouds. R. B. Mason and C. S. Taylor, *Ind. Eng. Chem., Ind. Ed., 32,* 67- 8 (1940). Apparatus and tests are described.

(1524) Effect of Ozone on Metal Dusts. H. Schütza and I. Schütza, *Z. anorg. allg. Chem., 245,* 59-66 (1940). Action of ozone on metal powder particles with regard to the formation of a protective coat of oxides, with the metal diffusing through the oxide film to the surface. Pulverization of Pb in ozone.

(1525) Spontaneously Combustible Zinc Dust Residues as the Cause of Fires. S. Wehrli, *Chem. Fabrik, 13,* 362-3 (1940). Discussion of causes and preventive measures.

(1526) Explosions from Metallic Dusts. *Chem. Age (London), 45,* 12 (1941). Hazards demanding further investigations include those of zinc dust.

(1527) Dust Explosion Hazards from Metal Powders. *Metallurgia, 25,* No. 1, 25-27 (1941). Metals, such as Fe, Zn, Al, Sn, in form of a powder can burn with great rapidity and explosive violence.

(1528) Report of Committee on Dust Explosion Hazards. *Natl. Fire Prot. Assoc. Quart., 34,* 5-15 (1941). Includes reference to Al, Mg and Zn powder explosiveness.

(1529) Bases of Safety in Light and Ultra-Light Alloy Manipulation. H. Berger, *Light Metals, 4,* 45-53 (1941). The nature of metal powder explosion is described, and protective clothing used in the light metal industry is discussed.

(1530) Dust Explosion Hazards in Plants Producing or Handling Aluminum, Magnesium or Zinc Powder. H. R. Brown, *U. S. Bureau of Mines Information Circ.,* No. 7148, 1941, 11 pp. Explosibility of metal dusts is treated.

(1531) Light Metal Fires. G. H. Durston, *Chem. Age (London), 45,* 63 (1941). Mg powder fires are easier to create than fires in Al powder, the difference in temperature is considerable; Al powders burn with much greater heat.

(1532) Influence of the Physical State of the Solid Reagents on the Equilibrium of Fe/Fe_3O_4 with H_2O/H_2. R. Fricke, K. Walter and W. Lohrer, *Z. Elektrochem., 47,* 487-500 (1941). A study made of this effect includes pulverulent solid reagents.

(1533) Solubility of Deuterium in Nickel. A. Sieverts and W. Danz, *Z. anorg. allgem. Chem., 247,* 131-34 (1941). Ni powder was heated in streaming H_2 at 1050-1100° C. (1920-2010° F.), then agitated with deuterium and the absorption measured.

(1534) Columbium and Hydrogen and Deuterium. A. Sieverts and H. Moritz, *Z. anorg. allgem. Chem., 247,* 124-30 (1941). The sorptive and solubility relations between the metal and the gases are discussed on the bases of experimental data; reference is made to the metal in powder form.

(1535) Inflammability of Metal Powders. *Ind. Eng., 111,* No. 4, 105 (1942). Ignition temperature determined.

(1536) Equilibrium of CO_2-Co Against Ni-NiO. R. Fricke and G. Weitbrecht, *Z. Elektrochem., 48,* 87-110 (1942). A study is made of the influence of the physical state of the solid, pulverulent reagents on the equilibrium of CO_2/Co with Ni/NiO.

(1537) Reactions of Solids (126th Report): Degassing of Solid Materials. G. F. Hüttig, *Z. anorg. allgem. Chem., 249,* No. 1, 134-145 (1942). Tests on Cu, Fe and Sn, Ni powders by H. Theimer and W. Breuer are described.

(1538) Rusting of Fritted Iron Powders in Its Relation to Previous Heat Treatments. G. F. Hüttig and K. Arnestad, *Z. anorg. allgem. Chem., 250,* No. 1, 1-9 (1942). Three samples of powdered Fe subjected to identical heat treatments and compared as to oxidizability and speed of reaction with $FeCl_3$ solution.

(1539) Reactions of Solids (130th Report): The Degassing of Fe Powders of Various Sources and Treatments. G. F. Hüttig and H. H. Bludau, *Z. anorg. allgem. Chem., 250,* No. 1, 36-41 (1942). The gases included in eight samples of powdered iron were determined and found to vary with method of preparation employed.

(1540) Oxidation of Copper Powder. R. W. Lawrence and J. H. Walton, *J. Phys. Chem., 46,* No. 6, 609-610 (1942). Effect of inhibitors on rate of oxidation of Cu powder by O in phosphoric acid solution.

(1541) Hazards in the Production and Use of Metal Powders. E. Pletch and T. Edwardsen, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chapt. 50, pp. 546-550. Control of accidents by fire and explosions. Inhalation and skin infections during manufacture. Toxic powders.

(1542) Reducibility of Iron Oxide with Hydrogen, with Small Amounts of Foreign Gases. K. Sedlatschek, *Z. anorg. allgem. Chem., 250,* No. 1, 23-35 (1942).

Reduction of FeO in rotary furnace. Examination of the products. Influence of changing quantities of H. Decrease of oxygen content by addition of foreign gases.

(1543) Production of Manganese by Electrolysis. P. L. Dubois-Valette, *Compt. rend., 216,* No. 19, 636-38 (1943). The pyrophoric properties of manganese powder obtained from electrolytic manganese amalgams are given.

(1544) Inflammability and Explosibility of Metal Powders. I. Hartmann, J. Nagy and H. R. Brown, *U. S. Bureau of Mines Report Invest. No. 3722,* 1943, 44 pp.; *Metal Ind. (London), 65,* 103 (1944). Processes generally employed in production of metal powders; uses; 53 powder samples were tested, including 14 different metals and 2 alloys; test equipment and procedure. Results of inflammability and explosion tests: inflammability high for Zr, Mg, Al, Ti; moderate for Fe, Mn, Zn, Si, Sn; little or none for Pb, Cd, Cu, Cr; reduction of inflammability and explosibility through use of inert gas; fire hazards.

(1545) Influence of the Atmospheric Factors of Production on the Chemical Activity and the Grain Distribution of Powders. J. A. Hedvall and A. Lundberg, *Arkiv. Kemi Mineral. Geol., 17A,* No. 12, 11-17 (1943). Previously published work on the effect of the gas pressure used in the preparation of powders on the chemical properties of the powders is reviewed and new data on the properties of Fe_2O_3 and CaO prepared in vacuum and under normal air pressure are presented.

(1546) Reactivating Agents for Solid Materials. J. A. Hedvall, *Ber. deut. keram. Ges., 24,* 318-320 (1943). Theory underlying reactions in mixtures of powders.

(1547) Influence of the Gaseous Atmosphere During the Production of Powder Samples on Their Chemical Activity and Surface Formation. J. A. Hedvall and A. Lundberg, *Kolloid-Z., 104,* No. 2/3, 198-203 (1943). Experiments are reported on SiO_2 and Al_2O_3 with various atmospheres such as oxygen, nitrogen, air, SO_2 and SO_3. Effect of temperature is studied.

(1548) Reactions of the Type A Solid plus B Solid Equals AB Solid. G. F. Hüttig, *Kolloid-Z., 104,* No. 2/3, 189-198 (1943). Results of chemical reactions of solids; the second part covers changes of powder mixtures of Cu-Sn during the course of gradual annealing.

(1549) Control of Magnesium Dust. J. M. Kane, *Trans. Am. Foundrymen's Assoc., 51,* 228-34, 234-43 (1943). Now it is possible to make specific comments on the fundamentals covering Mg dust control. The ease with which Mg dust can be ignited is its critical characteristic.

(1550) Safety in Handling Aluminum Powders. F. B. Rethwisch and G. M. Babcock, *Chem. & Met. Eng., 50,* No. 1, 82-4 (1943). Experience at Reynolds Metals Co. in producing metallic powders. Safety programs offered for concerns beginning operations.

(1551) *Natl. Fire Prot. Assoc. Report of Committee on Dust Explosion Hazards Quart., 37,* No. 4, 3-50 (1944). Codes for prevention of dust explosion in plastic industry. Fire protection in plants handling Mg powder or dust are reported.

(1552) Adsorption of Hydrogen on Tungsten Powders. W. G. Frankenburg, *J. Am. Chem. Soc., 66,* 1827-37, 1838-47 (1944). The main part of the measurement deals with the determination of the adsorption equilibria established on W powders at various temperatures and H pressures.

(1553) *Natl. Fire Prot. Assoc. Report of Committee on Dust Explosion Hazards Quart., 38,* No. 4, 5, Pt. II, 10-45 (1945). Codes for prevention of dust explosion in plastics industry and fire protection in plants producing Mg powder.

(1554) Explosibility of Metal Powder Dust Clouds. I. Hartmann and H. P. Greenwald, *Mining and Met., 26,* No. 463, 331 (1945). Ignition sources, factors affecting explosibility, fineness and concentration, test data on explosibility, reducing the explosion hazards and some preventive measures.

(1555) Water as Oxidizing Agent in Inflammable Mixtures. A. A. Shidlovsky, *Compt. rend. acad. sci. (U. R. S. S.), 51,* No. 2, 131-3 (1946). Experiments carried out on Al and Mg powders.

(1556) Adsorption of Hydrogen on Tungsten Powder. G. Halsey and H. S. Taylor, *J. Chem. Phys., 15,* No. 9, 624-30 (1947). An analysis of the experimental data of W. G. Frankenburg, *J. Am. Chem. Soc., 66,* 1827-38, on adsorption of hydrogen by W powder between -194 and 750° C. (-317 and 1332° F.) was made, using the Fowler-Guggenheim treatment of adsorption phenomena as the mode of approach.

(1557) Tungstic Acids. Studiengesellschaft Hartmetall. F. D. Rept. No. 3829/47 (1947). Analytical reports on various tungstic acids, dating from 1940, are given.

(1558) Reactivity of Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3867/47 (1947). It was reported in 1941 that TiC reacted noticeably with Cr_2O_3, WO_3 and Fe_2O_3 at 1500° C. (2730° F.) under vacuum, but not with silica, alumina or thoria.

(1559) Kinetics of Oxidation of Aluminum Powder. H. N. Terem, *Compt. rend., 224,* 1351-3 (1947). Oxidation of 250 mesh, 99.99% Al powder investigated at temperatures of 450-565° C. (850-1050° F.) in moist and dry air. Results do not agree with Valensi law of oxidation but conform to Arrhenius law.

(1560) Diffusion of Atomic Hydrogen Into Iron. A. M. Binet and J. Duflot, *Oesterr. Chem. Ztg., 49,* No. 10/11, 182 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 74. Atomic H is incorporated into Fe by cathodic discharges, but it desorbs spontaneously at room temperature. The influence on the diffusion was examined by several discharges at fixed intervals, by collecting the liberated gas.

(1561) Facilitation of Powder Reactions by Lattice Disturbances in Original Material. R. Fricke, *Met. Powd. Rept., 2,* No. 12, 182 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 176 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 3. Cadmium ferrite and zinc ferrite have been prepared from the mixed oxides at temperatures 200° C. (360° F.) lower than the normal temperature of formation, when the oxide lattices contained irregular, but well-defined disturbances. Activated copper was oxidized at 200° C. (390° F.), as compared with normal copper which reacted only at about 650° C. (1200° F.).

(1562) Explosion Hazard of Metal Powders and Preventive Measures. I. Hartmann, *Metals Handbook, Am. Soc. Metals, Cleveland,* 1948, pp. 53-54. Explosibility factors; classification of metal powders; preventive measures.

(1563) Surface Activity and Powder Metallurgy. J. A. Hedvall, *Met. Powd. Rept., 2,* No. 12, 181 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 176 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 48. The peculiar activity and mobility of surface material are subject to control, as with catalysts and adsorbents, the methods of control being discussed with diagrams. A mechanical mixture of CoO and NiO alloys and recrystallizes more readily than a corresponding solid solution. Relation to behavior of metal and alloy powders discussed.

(1564) Some Wetting Properties of Metal Powders. B. Kopelman and C. C. Gregg, *Trans. Am. Soc. Metals, 41,* 293-302 (1948). The wetting characteristics of metals and metal oxides were investigated by the examination of suspensions of powders in kerosene and CCl_4-H_2O mixture, without and with a wetting agent. Higher melting metals are more difficult to disperse than lower melting metals.

(1565) Application of Adsorption Measurements to Powder Metallurgy Problems. H. Schreiner, *Met. Powd. Rept., 2,* No. 12, 192 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 188 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 23. After giving a short introduction to the adsorption, the author shows that the results can also be evaluated to give information on the pore size distribution. Investigation of sintered powders is shown on the adsorption of methane vapor on copper powder, electrolytically produced. Investigation also concerns itself with unsintered powders.

(1566) Relative Reducibility of Some Iron Oxides. E. P. Barrett and C. E. Wood, *U.S. Dept. Int. Bur. Mines Rept. of Invest. No. 4569,* 1949. Preparation of the materials for deoxidation tests. Variables affecting the deoxidation; activators.

(1567) Relation between Adsorption and Corrosion. G. F. Hüttig, *Berg- und Hüttenmännische Monatshefte, 94,* No. 8/9, 282-4 (1949). Investigation of theory with example given of carbonyl iron powder; diagrams.

(1568) Temperature of Flames Containing Incandescent Particles. H. G. Wolfhard and W. G. Parker, *Proc. Phys. Soc., B62,* 523-29 (1949). The true temperature of burning aluminum powder or magnesium powder differs widely from the color temperature, optical anomalies being introduced through the small size of the radiant particles.

C. Other Properties and Behaviors (e. g. medical)

(1569) Toxicology of the Carbonyls. A. J. Amor, *J. Ind. Hyg., 14,* 216-21 (1932). Metal carbonyls are toxic when injected or inhaled. Nickel carbonyl is at least 5 times as toxic as carbon monoxide. Toxic symptoms and treatment are discussed.

(1570) Nickel Carbonyl Poisoning. W. W. Brandes, *J. Am. Med. Assoc., 102,* 1204-6 (1934). A report is given on a case of $Ni(CO)_4$ poisoning.

(1571) Action of Finely Divided Magnesium on the Lungs. A. B. Delahant and L. U. Gardner, *Am. J. Public Health, 33,* 153-56 (1943). Metallic Mg does not have the same effect on lungs as that which it exerts in the more dense subcutaneous tissues.

(1572) Health Hazards in the Aluminum Industry. G. Goralewski, *Deut. Tuberkul. Blatt, 17,* 3-10; *Chem. Zentr., 114,* Pt. II, 2178 (1943). Pathological pulmonary changes in subjects working in the aluminum powder industry were studied by frequent progressive roentgenological tests.

(1573) Powder Metallurgy and Industrial Hygiene. J. D. Shaw and W. V. Knopp, *Quart. Am. Ind. Hyg. Assoc., 7,* No. 4, 26-28 (1946). The preparation of metal powders by milling, graining, atomization, sintering is discussed in relation to industrial hygiene.

(1574) Hygiene in Metal Powder Industry. D. R. Johns, *Proc. Fifth Ann. Spring Meeting, Met. Powder Assoc.,* Chicago, Apr. 5-6, 1949, pp. 51-57. Diseases due to industrial dusts are discussed.

4. TESTING AND CONTROL METHODS AND EQUIPMENT FOR POWDERS

(1575) Tests of Zinc Dust for Cyaniding. W. J. Sharwood, *Eng. Mining J., 93,* 943-6 (1912). Chemical and mechanical methods for examining Zn dust are given with the results and conclusions. The efficiency of Zn dust in cyaniding depends on the fineness, so at least 95% should pass 200 mesh.

(1576) Specifications for Gold Bronze Powder. *Am. Soc. Test. Materials Standards, 41,* Pt. II, 204-5, D267-41 (1941). Composition and properties, and methods of testing are specified.

(1577) Methods of Sampling and Testing Aluminum Powder. *Am. Soc. Test. Materials Standards, 41,* Pt. II, 378-381, D480-41 T (1941). Sampling. Qualitative analysis. Leafing. Properties. Coarse particles. Stability.

(1578) Testing Stand for Magnetic Powders. R. Berthold, *Z. Ver. deut. Ing., 87,* No. 25, 399-401 (1943). The apparatus and its use is described.

(1579) Special Tests and Standards to Be Used in Powder Metallurgy. J. F. Sachse, *Iron Age, 153,* No. 22, 55-56 (1944). Abstract of paper presented at the First Annual Spring Meeting of the Metal Powder Assoc., New York, May 5, 1944.

Sachse describes testing of the properties and the differences between flake and granulated types of powders.

(1580) Tentative Method for Sampling Finished Lots of Metal Powders. *Metal Powder Association. M.P.A. Standard 1-45T*, 1945, 2 pp. Describes the procedures used for the removal of representative samples of finished lots of metal powders. Part I concerns those powders blended in mechanical blending equipment, and Part II those powders blended manually.

(1581) Testing Methods in Use in Determining the Properties of Iron Powder. J. E. Drapeau, *Proc. Second Ann. Spring Meeting Met. Powd. Assoc., New York*, June 13, 1946, pp. 60-64. Microscopic examination, classifying, testing of apparent density and green strength.

(1582) Specifications for Zinc Dust. *Am. Soc. Test. Materials Standards, 47*, Pt. II, 148, D 520-47 (1947). Composition and properties. Method of testing.

(1583) Some Properties of Engineering Iron Powders. C. J. Leadbeater, L. Northcott and F. Hargreaves. *Symposium on Powder Metallurgy.* The Iron & Steel Inst. Special Rept. No. 38, London, 1947, pp. 15-36; *Metal Powd. Rept., 1*, No. 6, 91 (1947). Study of properties of 28 commercial Fe powders. Standardization and development of testing methods, apparent and tap densities, surface texture, crystal structure, gas content; paper also includes data on behavior of parts, when pressed and sintered.

(1584) Microchemistry and Powder Metallurgy. G. Gorbach, *Oesterr. Chem. Ztg., 49*, No. 10/11, 186 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 72. Quantitative methods of microchemistry are also applicable for tests in powder metallurgy. Description of the apparatus used in the Institute for Biochemical Technology in Graz.

A. Particle characteristics, (size, shape, surface and structure)

(1585) Recent Determinations of Molecular Refractions and Dispersions. J. H. Gladstone, *Chem. News, 67*, 94-95 (1893); *Phil. Mag., 35*, No. 5, 204-06 (1893). Metal carbonyls are used among other substances in the determinations.

(1586) The Stokes Law. G. G. Stokes, *Mathematical and Physical Papers.* Cambridge Univ. Press, 1901, 412 pp. A derivation is given of Stokes' law in which the terminal settling velocity of a single spherical particle falling at low velocity in a quiescent, homogeneous fluid of infinite extent is related to the diameter of the sphere.

(1587) Limitations Imposed by Slip and Inertia Terms upon Stokes' Law for the Motion of Spheres through Liquids. H. D. Arnold, *Phil. Mag., 6*, No. 22, 755-75 (1911). It is possible to make metallic spheres small and of uniform density and surface texture to verify Stokes' law as applied to less viscous oils.

(1588) Grading Analyses by Elutriation. H. Stadler, *Trans. Inst. Mining Met. (London), 22*, 686-701 (1912/13). The velocity attained in settling is governed by two different laws: *(1)* the law of eddying resistance, and *(2)* the law of viscous resistance.

(1589) Method of Mechanical Soil Analysis. S. Oden, *Proc. Roy. Soc. Edinburgh, 36*, 219-20 (1916). The development of the sedimentation balance is described.

(1590) Automatic Recording Method of Mechanical Soil Analysis. S. Oden, *Bull. Geol. Inst. Univ. Upsala, 16*, 15-16 (1917). A discussion is given of particle size determination with the sedimentation balance.

(1591) Manometric Sedimentation. G. Wiegner, *Landw. Vers. Sta., 91*, 40-50 (1918). A method of particle size determination based on density changes of a suspension is developed.

(1592) Photomicrographic Method for the Determination of Particle Size of Paint and Rubber Pigments. H. Green, *J. Franklin Inst., 192*, 637-66 (1921). The

methods for the direct linear measurements of particle size by means of the microscope are discussed.

(1593) Estimation of Colloidal Constituents in Tungsten Powder. A. Lottermoser, *Kolloid Z., 30,* No. 1, 53-61 (1922). By a sedimentation process and optical control of the sedimentation tests.

(1594) A Method for the Determination of the Surface Area of Adsorbing Powders. F. Paneth and W. Vorwek, *Z. physik. Chem., 101,* 445-88 (1922). A determination of the specific surface is made by measurement of the surface adsorption by the powder of a solution containing a radioactive lead isotope. The sorption process is followed with the aid of the electroscope.

(1595) T. Svedberg, *Die Methoden zur Herstellung Kolloidaler Lösungen.* Steinkopf, Dresden, 1922, 507 pp. On pp. 377 to 411 a discussion of the sedimentation balance is presented.

(1596) Determination of the Surface of Glass Powder. H. Wolff, *Z. angew. Chem., 35,* 138-40 (1922). The determination is based on data of the rate of solution.

(1597) General Law of Fall of a Small Spherical Body through a Gas. R. A. Millikan, *Phys. Rev.,* Ser. II, *22,* 1-23 (1923). Discussion of errors introduced in elutriation methods of determining particle size by particles comparable in size with the intermolecular distances in the elutriating fluid.

(1598) Meaning and Microscopic Measurement of Average Particle Size. G. S. J. Perrott and S. P. Kinney, *J. Am. Ceram. Soc., 6,* 417-39 (1923). Microscopical particle sizing is discussed and its mathematical interpretation is presented. A description is given of metallographic mountings of powdered materials.

(1599) Remarks on the Article of A. Lottermoser "Technical Estimation of the Colloidal Component in Tungsten Powders". J. A. M. Van Liempt, *Kolloid Z., 32,* 118-9 (1923). A third method is the decomposition of hydrogen superoxide on the surface of the tungsten particles.

(1600) On Adsorption. G. C. Schmidt and F. Durau, *Z. physik. Chem., 108,* 128-150 (1924). The surface adsorption and the rate of solution of powdered materials are used to determine the specific surface of the powder.

(1601) Size and Character of Non-Metallic Mineral Fillers. W. M. Weigel, *U. S. Bur. Mines,* Tech. Paper No. 296, 1924. Direct linear measurements of size may be made by direct observation using a filar micrometer or an eyepiece disk micrometer.

(1602) Determination of the Granular Size of Tungsten Powder. C. Agte, K. Schroter and H. Schönborn, *Z. tech. Physik, 6,* 293-96 (1925). Four test methods are given.

(1603) A Source of Error in the Mechanical Analysis of Sediments by Continuous Weighing. J. R. H. Coutts and E. M. Crowther, *Trans. Faraday Soc., 21,* 374-80 (1925). Work with the Oden sedimentation balance disclosed that the balance pan sets up convection currents which cause systematic errors in the sedimentation data.

(1604) The Theory of Fine Grinding II. A Method of Accurately Determining Experimentally the Surface of Crushed Sand Particles. G. Martin, E. A. Bowes, and J. W. Cristelow, *Trans. Ceram. Soc., 25,* 51-62 (1925/6). Measurement of the specific surface by the determination of the rate of solution is described.

(1605) N. B. Nichols and H. Liebe, *Colloid Symposium Monograph Minnesota, 3,* 268 (1925). A modification of the sedimentation balance is described.

(1606) J. Alexander, *Colloid Chemistry,* Chemical Catalog Co., New York, 1926. On pp. 861 ff., the theoretical principles underlying the sedimentation and elutriation methods of particle size determination are presented.

(1607) Sedimentation Analysis and Its Application to the Physical Chemistry of Clays and Precipitates. S. Oden, *Colloid Chemistry, I.* Edited by J. Alexander. Chemical Catalog Co., 1926, 973 pp., Chap. 58. A detailed discussion is presented of the theories and practices of particle size determinations by sedimentation analysis.

(1608) Particle Size and Distribution by Sedimentation Method. J. H. Calbeck and H. R. Harner, *Ind. Eng. Chem., Ind. Ed., 19,* 58-61 (1927). Discussion of the use and theory of the sedimentation balance for measuring the rate of sedimentation of a pigment shaken in a liquid.

(1609) Effect of Non-Uniformity and Particle Shape on Average Particle Size. H. Green, *J. Franklin Inst., 204,* 713-29 (1927). Discussion of the effect of the shape factor in the calculation of particle size.

(1610) Contribution to the Knowledge of Milled Products. A. H. M. Andreasen, *Kolloidchem. Beihefte, 27,* 349-58 (1928). Methods of particle size determination and sedimentation are presented.

(1611) O. v. Baeyer and U. Gerhardt, *Die Interferometrische Messung im Ultramikroskop.* Bornträger, Berlin, 1928, 23 pp. On p. 2 it is stated that particles 0.2 micron and larger are made visible, and their measurements are still accurate.

(1612) Grain Size Determination with the Aid of X-Rays. R. Brill, *Z. Krist., 68,* No. 4, 387-403 (1928). Determination of grain size of carbonyl Fe according to Debye-Scherrer method. Compared with von Laue method.

(1613) Air Elutriator. H. W. Gonell, *Z. Ver. deut. Ing., 72,* 945-50 (1928). Description of apparatus and procedure developed at Staatliches Materialprüfungsamt, Berlin-Dahlem.

(1614) F. V. v. Hahn, *Dispersoidanalyse.* Steinkopff, Dresden-Leipzig, 1928, 553 pp. The application of Stokes' law is treated. Different particle size analyses, especially those based on optical methods, filtration and diffusion methods are comprehensively covered.

(1615) Measurement of Ultrafine Particles with the Wiegener Sedimentation Apparatus. H. Kühl and J. Tokune, *Zement, 17,* 256-61 (1615). Work is performed on Portland cement.

(1616) Adsorption Measurements With An Improved Microbalance. R. Strömberg, *Kgl. Svenska Vetenskapsakad. Handl., Ser. 3, 6,* No. 2, 1-122 (1928). Suitable for mineral and metal powders.

(1617) Methods of Particle Size Determination. L. T. Work, *Proc. Am. Soc. Test. Materials, 28, Pt. II,* 771-812 (1928). A graphic analysis of fineness distribution curves for pulverized materials is made; a method of particle size determination is described, whereby the number of particles falling within arbitrarily established micron ranges are counted when examining slides of the powder microscopically.

(1618) Elutriation Rate and Particle Size. A. H. M. Andreasen and J. J. V. Lundberg, *Kolloid-Z., 49,* 48-51 (1929). An apparatus with a single column is used, and fractionation is obtained by applying successively higher rates of flow of the elutriation liquid.

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(1729) Particle Size Determination for Control of Tungsten Products. M. F. Rogers, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 15, pp. 173-181 (1942). Excellent results in practical control secured. Two different methods used.

(1730) Laboratory Sizing. R. Schuhmann, Jr., *Powder Metallurgy*, Am. Soc. Metals, Cleveland, 1942, Chap. 17, pp. 186-213. Particle size, size scale, distribution, specific surface, sedimentation sizing, classification, sieving.

(1731) The Permeability Method for Determining Specific Surface of Fibers and Powders. R. R. Sullivan and K. L. Hertel, *Advances of Colloid Science*, Vol. I, E. O. Kraemer, editor, Interscience, New York, 1942. On pp. 37 ff., the permeability method as a means of particle size determination is presented.

(1732) Use of the Microscope in Particle Size Analysis. G. L. Fairs, *J. Soc. Chem. Ind., 62*, No. 40, 374-78 (1943). A definition of particle size is given. Included also is the preparation of the dispersion for examination and the method for making the count. The microscope equipment is described, and a comparison is made of results with those obtained by photo-sedimentation and turbidimeter.

(1733) Fine Crystalline Powders. W. D. Harkins and G. Jura, *J. Chem. Phys., 11*, No. 9, 430-431 (1943). An absolute method for determination of the area of a fine crystalline powder. In order to determine the area of FeO_2 powder it is outgassed in a Pyrex tube, then connected to another tube which contains a liquid.

(1734) Use of the Microscope in Particle Size Analysis. G. Lowrie-Fairs, *Chemistry & Industry, 62*, 374-78 (1943). Use of the microscopic method described yields accurate size analysis of dispersions in the sub-sieve range.

(1735) The Graphitization of Thermax-Carbon Black. A. Ragoss, U. Hofmann and R. Holst, *Kolloid-Z., 105*, 118-24 (1943). Measurement of particle size as a function of temperature in the supermicroscope is described.

(1736) Measurement of the Fineness of Powdered Materials. P. J. Rigden, *Chemistry & Industry, 62*, 393-6 (1943). Size analysis by elutriation, sedimentation, microscopic study, determination of total surface area, etc. Various methods reviewed.

(1737) Rugosity of Granular Solids. R. H. S. Robertson and B. S. Emödi, *Nature, 152*, 539-40 (1943). The particle shape is determined quantitatively by statistical methods, and the degree of roughness is used as a parameter.

(1738) Examining of Metal Powders in the Electron Microscope. R. W. Schmidt, *Kolloid-Z., 102*, No. 1, 15-17 (1943). Possibility of oxidation of sample in high vacuum while being examined in the electron microscope, W powder as example: formation of fine W oxide needles on the particles of W powder, identification of the particular W oxide on the basis of experiments, oxidation of Mo powders in electron microscope.

(1739) Determination of Particle Size in the Sub-Sieve Range. British Colliery Owners' Research Association and British Coal Utilization Research Association, 1944. Measurement of size and shape of various powders.

(1740) Particle Size Determination of Metal Powders. *Iron Age, 153*, No. 24, 86-87, 166 (1944). The use of photocell to determine particle size makes available a simple method of calculating sizes of fine powders.

(1741) Adsorption of Hydrogen on Tungsten Powders. W. G. Frankenburg, *J. Am. Chem. Soc., 66*, No. 11, 1827-1837; 1838-1847 (1944). In part I, method and experimental results are presented; preparation of tungsten powders; general principle of the adsorption measurements; results in tables and curves. In part II, the isotherms and adsorption equilibria are studied.

(1742) Particle Size Measurement. P. G. W. Hawksley, *Brit. Coal Utilization Res. Assoc. Bull., 8, 245-57* (1944). 129 references. The research method is discussed on the projection microscope and on the photographic sedimentation.

(1743) Determination of Particle Size in Powder Metallurgy. P. R. Kalischer, *Can. Metals Met. Inds., 7*, No. 9, 34-37 (1944). Four methods for sizing fine powders discussed; microscope, air elutriation, liquid elutriation and gravitational fractionation.

(1744) Determination of Particle Size in Powder Metallurgy. P. R. Kalischer, *Trans. Electrochem. Soc., 85*, 153-62 (1944). Four methods for sizing fine powders are described; microscopic count, air elutriation, liquid elutriation, and gravitational fractionation.

(1745) Apparatus for Surface Area Measurement. K. A. Krieger, *Ind. Eng. Chem., Anal. Ed., 16,* No. 6, 398-399 (1944). Constructional details and use of the apparatus are described.

(1746) Fine Powders and Particles in Industry. M. Pirani, *Brit. Coal Utiliz. Res. Assoc. Bull., 8,* 361-74 (1944). Concludes that simpler and more effective method should be developed for determination of particle size or specific surface down to colloidal dimensions.

(1747) Rate of Sedimentation – Concentrated Flocculated Suspensions of Powders. H. H. Steinour, *Ind. Eng. Chem., Ind. Ed., 36,* No. 10, 901-907 (1944). Rates of sedimentation are reported for concentrated flocculated suspensions of various finely divided solids. Each powder embraced a wide range of particle sizes and was tested at a series of concentrations. A rate equation previously found was, in general, supported by new data.

(1748) Measurements in Dust Technology. A. Winkel, *Z. Ver. deut. Ing., 88,* 296-97 (1944). Electron microscopy photoelectric methods, wind sifting and aerometer methods are described.

(1749) Particle Size by Spectral Transmission. E. D. Bailey, Symposium on Measurement & Creation of Particle Size, Division of Industrial & Engineering Chemistry, American Chemical Society, Brooklyn Polytechnic Institute, December 27, 1945. A simple method is described which permits the evaluation of transmission measurements in the visible and infrared parts of the spectrum for the determination of two-parameter size distributions.

(1750) Light and Electron Microscopy of Pigments. D. G. Brubaker, *Ind. Eng. Chem., Anal. Ed., 17,* 184-87 (1945). A comparison is made between light and electron micrographs of small particle size powders.

(1751) Estimating the Average Surface Area of Solid Particles. H. M. Cassel, *J. Chem. Phys., 13,* No. 6, 249 (1945). It is assumed in this work that the contact angle at the liquid-crystal-vapor boundary is zero. However, the point has been overlooked that under this condition capillary condensation between the contacting crystals is inevitable.

(1752) Centrifugal Sedimentation Method for Particle Size Distribution. A. E. Jacobson and W. F. Sullivan, *Symposium on Measurements and Creation of Particle Size,* Division of Industrial & Engineering Chemistry, American Chemical Society, Polytechnic Institute of Brooklyn, Dec. 27, 1945. A centrifugal sedimentation method is described which is analogous to Oden's method of tangential intercepts for gravitational sedimentation.

(1753) Test Sieves and Sieving. A. A. Klein, Symposium on Measurement and Creation of Particle Size, Division of Industrial and Engineering Chemistry, American Chemical Society, Polytechnic Institute of Brooklyn, Dec. 27, 1945. The development of test sieves and the inadequacies of our present specifications considered.

(1754) Comparison of Two Methods for Determining the Surface Area of a Powder. R. C. Langille, P. E. Braid and F. B. Kenrick, *Can. J. Research, 23B,* No. 1, 31-39 (1945). Surface area of barium crown glass powder determined by *(1)* comparison of methylene blue on the powder and on large broken surfaces; *(2)* measurement of the projection areas of randomly oriented particles.

(1755) A Rapid Optical Method for Estimating the Specific Surface of Powders. E. Sharratt, E. H. S. Van Someren, and E. C. Rollason, *J. Soc. Chem. Ind., 64,* 73-75 (1945). Estimating surface areas from an observation of the optical density of their dilute suspensions.

(1756) Particle Size Analysis of Iron Powders In Powder Metallurgy. H. H. Steinour, *Iron Age, 155,* No. 20, 65-71 (1945). Comparison of the particle size analysis of 5 commercial Fe powders obtained by Wagner turbidimeter method shows close agreement in 4 out of 5 cases with computed recombination of the fractions.

(1757) Absolute Surface of Finely Divided Material. P. A. Thiessen, *Naturwiss., 32,* 158-159 (1945). The surface area of a fine dispersion can be detected by adsorbing on it ultramicroscopically visible particles of a second test colloid like Au solution. The number of test particles adsorbed is then counted microscopically.

(1758) Electron Microscopy of Catalysts. J. Turkevich, *J. Chem. Phys., 13,* No. 6, 235-39 (1945). The paper is a survey of the appearance in the electron microscope of a number of catalysts in powder form.

(1759) Particle Size Analysis of Metal Powders. Metals Disintegrating Co., Elizabeth, N. J., 1946, 36 pp. A detailed description of various methods including Roller analyzer, Wagner turbidimeter, and microscopic count.

(1760) Method of Analysis for the Particle Size Distribution of Sub-Sieve Size Substances. Am. Soc. Test. Materials Standard Designation: E20-33T; Proc. 46, Pt. II, 1668, (1946). Method of microscopic sizing and technique.

(1761) Particle Size Determination from X-Ray Line Broadening. L. S. Birks and M. Friedman, *J. Applied Phys., 17,* No. 8, 687-692 (1946). X-ray line broadening method of determining particle size was compared with direct measurements on electron micrographs. By controlled heating of the carbonate, Mg oxide particles were prepared from 50 to 1000 Å in diameter. Particle size calculated from x-ray data taken on a Geiger counter spectrometer agreed to $\pm$10% with the microscope measurements.

(1762) Adsorption of Nitrogen and Finely Divided Tungsten Powder. R. T. Davis, *J. Am. Chem. Soc., 68,* 1395-96 (1946). Adsorption isotherms were established for pressure range of 10^{-6} – 35 mm. and at temperatures between 400-750° C. (750-1380° F.), *i. e.,* under conditions similar to those employed in a previous study by W. G. Frankenburg, *J. Am. Chem. Soc., 66,* 1827-1847 (1946) of hydrogen adsorption of W powder.

(1763) Measuring the Distribution of Particle Size in Dispersed Systems. W. M. Dotts, *Ind. Eng. Chem., Anal. Ed., 18,* 326-28 (1946). A special method of liquid elutriation is described.

(1764) Preparation of Standard Powders for Reference in Particle Size Measurement. E. L. Gooden and R. L. Updike, Jr., *Ind. Eng. Chem., Anal. Ed., 18,* No. 12, 802 (1946). Two types of uniform-particle size powders can be prepared by a small amount of processing with common laboratory equipment.

(1765) Application of Sizing Analysis to Mill Practice. H. Heywood and E. J. Pryor, *Bull. Inst. Mining Met.,* No. 477, 1-10 (1946). A discussion of average particle shape, surface and energy and sizing methods as related to mineral dressing for the purpose of control.

(1765A) A Comparison of Methods of Measuring Microscopical Particles. H. Heywood, *Bull. Inst. Mining Met.,* No. 477, 1-14 (1946). An attempt to determine the probable accuracy of size estimates made by different observers and also the effect of irregularity of shape on the estimates.

(1765B) Study of Sizing Analysis by Sieving. H. Heywood, *Bull. Inst. Mining Met.,* No. 477, 1-18 (1946). Measurements made on crushed sandstone particles.

(1766) Dispersion Media for Metal Powders. H. Heywood, *Proc. Inst. Mech. Engrs. (London), 154,* 213 (1946). Written communication to paper of J. E. Newson, *ibid, 154,* 208-213 (1946). Particle size determination by sedimentation methods depends on complete dispersion of the particles.

(1767) Scope of Particle Size Analysis and Standardization. H. Heywood, *Trans. Inst. Chem. Engrs.; Soc. Chem. Ind. (London),* Adv. Copy Feb. 4, 1947; *Met. Powd. Rept., 1,* No. 7, 110 (1947). The physical properties of sieving, microscopical measurement, elutriation, sedimentation and centrifuging are outlined.

(1768) Determination of Specific Surface by Permeability Measurements. W. F. Keyes, *Ind. Eng. Chem., Anal. Ed., 18,* No. 1, 33-34 (1946). Effect of porosity upon the air permeability of a number of powders is determined and a modified equation for the relationship between permeability, specific surface and porosity is developed on the basis of the experimental results.

(1769) Tentative Method for Sieve Analysis of Granular Metal Powders. Metal Powder Association, M.P.A. Standard 5-46T, 1946, 3 pp. Describes apparatus and procedures used in the sieve analysis of granular metal powders.

(1770) Rapid Method for Determining Specific Surface of Fine Particles. A. Pechukas and F. W. Gage, *Ind. Eng. Chem., Anal. Ed., 18,* 370-73 (1946).

The Lea and Nurse method of determining the specific surface of fine powder using gas permeabilities has been modified for measuring particles of less than 1.0 micron.

(1771) Size Grading of Diamond Powders. B. L. Steierman, H. Insley and W. H. Parsons, *J. Research Natl. Bur. Standards, 36,* 469-470 (1946). Some 30 dispersing agents were tested of which a 0.1-0.25% solution of gelatin in water was found best and most economical.

(1772) Determination of the Shape of Particle of Finely Ground Powder. A. D. Steinherz, *J. Soc. Chem. Ind., 65,* 314-320 (1946). The usual particle size analysis gives data on particle size distribution by weight, or values of a function related to the surface area of particles of the same weight.

(1773) Particle Size Distribution of Iron Powder. H. H. Steinour, U. S. Dept. Comm. PB. 17644/1944, 13 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 23, 1412 (1946). The initial report is concerned with preliminary matters regarding the equipment, the identification and the appearance of the iron powders for the study. For other reports see PB. 17645-47.

(1774) Particle Size Distribution of Iron Powders. H. H. Steinour, U. S. Dept. Comm. PB. 17645-47/1944, 21 pp., 17 pp., 50 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 21, 1253 (1946). Size analysis by a modified Wagner turbidimeter method Fe powder is separated by air elutriation into portions of different finenesses. The air-permeability method of determining the specific surface gave good results.

(1775) Electron Microscope in Metallography. J. Hunger and F. Pawlek, *Arch. Metallkunde, 1,* No. 9/10, 385-386 (1947). The electron microscope is suitable for stereoscopic observations, because the metal specimens would have to be ground extremely thin; to make them pervious to electron radiation, replica methods are used.

(1776) Method for Determination of Particle Size Distribution. A. E. Jacobsen and W. F. Sullivan, *Ind. Eng. Chem., Anal. Ed., 19,* 855-856 (1947). Results with ground ilmenite; titanium dioxide pigments are obtained by a sedimentation balance with tall cylinder for materials down to 1 micron.

(1777) Iron Powder Compacts and Powders for Microscopic Examination. H. Jamison and E. S. Bryon, *Metal Progress, 51,* No. 3, 437-40 (1947). Sampling and sectioning, mounting, grinding, final polishing, photomicrographs of finished compacts.

(1778) Determination of Specific Surface of Iron Powders by a Modification of the Air-Permeability Method. F. M. Lea, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Report No. 38, London, 1947, pp. 35-36. A modified air-permeability apparatus was developed for very granular powders.

(1779) J. R. Musgrave and H. R. Harner, *Turbidimetric Particle Size Analysis.* The Eagle-Picher Research Labs., Joplin, Mo., 1947, 47 pp. Development of the turbimetric method. Detailed operating instructions. Auxiliary information. Bibliography.

(1780) Sieve Tests of Metal Powders. R. E. Pollard, *J. Research of Natl. Bur. Stand., 39,* No. 6, 487-505 (1947). Reproducible results were obtained in sieve tests with sponge iron, electrolytic iron, and copper; with nickel only, when certain variables affecting the sieving characteristics of the powder were eliminated or controlled.

(1781) Particle Size Measurement in the Radio Industry. M. L. Smith, *Trans. Inst. Chem. Engrs.; Soc. Chem. Ind. (London),* Adv. Copy Feb. 4, 1947, 77-89; *Metal Powd. Rept., 1,* No. 7, 110 (1947). A wide variety of powders were examined, including tungsten and molybdenum powders for filament manufacture; magnetic powders; zirconium powder for getters; and copper, aluminum, tin and zinc powders.

(1782) Surface Properties of Tungsten Carbide Powder. Studiengesellschaft Hartmetall. F. D. Report No. 3881/47 (1947). According to this report of 1941, adsorption of methylene blue is more effective for studying the surface properties of tungsten carbide powder than x-ray measurements, rate of oxidation, treatment with boiling HNO_3, or measuring the tap density.

(1783) Particle Size Measurement. Studiengesellschaft Hartmetall. F. D. Report No. 3926/47 (1947). Instructions for the particle size measurement of boron carbide powder, dating back to 1942.

(1784) Apparatus for Air Classification of Metal Powders. E. C. Truesdale, *Proc. Third Ann. Spring Meeting Metal Powder Assoc.*, New York, May 27, 1947, pp. 35-51. A laboratory instrument based on air elutriation was developed and found capable of accurate fractionation at particle diameters up to 40 microns.

(1785) Sieve Analyses of Metal Powders. *Chem. Age (London), 58,* No. 1495, 334-6 (1948). Marked deviations resulting from variations in humidity and from segregation brought about repeated riffle cutting.

(1786) Particle Size Distribution in Powder Metallurgy. *Ceram. Age, 51,* No. 6, 324,328 (1948). Report on investigation covering conditions contributing to poor reproducibility of sieve analyses of metal powders. Micrographs of sponge iron powder made from reduced mill scale.

(1787) Particle Size Distribution in Powder Metallurgy. *J. Franklin Inst., 245,* No. 6, 517-20 (1948). In making sieve tests of sponge iron, electrolytic iron, copper and nickel, made for the purpose of accumulating supplies of sieved fractions, it was found that reproducible results could be obtained only when certain variables were controlled.

(1788) Air Grading of Sub-sieve Powders. *Indust. Diamond Rev., 9,* 19-22 (1948). The Roller air analyzer and the results obtained with the Fisher sub-sieve sizer are discussed.

(1789) Sieve Analyses of Metal Powders Affected by Atmospheric Humidity. *Steel, 122,* No. 8, 89-90, 116 (1948). Report on investigations by Natl. Bureau of Standards of methods of eliminating, controlling, or evaluating effects of variables encountered in sieve analyses of powders. Differences of as much as 10% between weight of fractions of powdered iron sieved under high and low humidities observed.

(1790) The Electron Microscope in Powder Metallurgy. R. Bernard, *Oesterr. Chem. Ztg., 49,* No. 10/11, 184 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 63. The electron microscope has the advantage of allowing the disintegration of the aggregates in elementary crystallites. While two powders show in the optical microscope grains of equal size, they may have different behavior during the sintering.

(1791) Classification of Powder Particle Size by Sieve. T. Burchell, *Murex Review, 1,* 33-38 (1948). Compares the British Standards, German, I.M.M., and Tyler screen sizes, with some practical hints on the technique of sieving.

(1792) Measurement of Grain Size of Tungsten Powder. H. Burden and A. Barker, *J. Inst. Metals, 75,* Pt. 2, 51-68 (1948). Tests with WC and W reduced by H_2 are described. Good correlation observed with the particle size with electron microscope. Coarse powders tend to decrease in grain size, and fine powders to increase; coarse powders give lower hardness. Bibliography.

(1793) Surface Area Measurement of Fine Powders. P. C. Carman and J. C. Arnell, *Can. J. Research, A26,* No. 3, 128-36 (1948). The several modified Kozeny equations for the measurement of the specific surface of fine powders by gas-permeability methods are compared.

(1794) Electron Microscope in Powder Metallurgy. P. Grivet, F. Bertein, H. Bruck and J. Robillard, *Revue Metallurgie, 45,* No. 1/2, 38-48 (1948). CSF and electronic diffraction microscopes and technique of examination of powders and metallic surfaces are discussed. Bibliography.

(1795) On Accuracy of Sieve Analyses Made by Sieving Machines. S. Mörtsell, *Trans. Roy. Inst. Tech.*, No. 17, 1-44 (1948). Short treatise, in English, describes some investigations that were made in Sweden during 1943-45.

(1796) Measurement and Control of Grain Size in Hard Metal Powders. P. W. Penrice, *Met. Powd. Rept., 2,* No. 12, 186; *Oesterr. Chem. Ztg., 49,* No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 73. A detailed account is given of the evaluation of grain size from the line thickness on x-ray photographs taken of specimens rotating at controlled rates.

(1797) Graphic Representation of Sieve Analysis on Rosin-Rammler Equation. E. Puffe, *Z. Erzbergbau Metallhüttenw., 1,* 97-102 (1948). Feasibility of sieve analysis and its representation in form of tables.

(1798) Granulometric Analysis by Sedimentation. N. Thien-Chi, *Métaux et Corrosion, 23,* No. 274, 137-46 (1948). Applications to powder metallurgy are discussed.

(1799) Feret's Statistical Diameter as a Measure of Particle Size. W. H. Walton, *Nature, 162,* No. 4113, 329-30 (1948). Various measurements of the size of irregularly shaped particles as seen in profile under the microscope are discussed.

(1800) Determination of the Texture of Iron Powders. L. Weil, *Compt. rend., 227,* No. 1, 48-50 (1948). Determination of the texture of iron powders of high coercive force by measurement with a calorimeter of their heat of pulverization in organic liquids (*e. g.*, benzine) and comparing it with iron granules produced of carbonyl powder under the microscope.

(1801) Particle Size Distribution in Powder Metallurgy. *Ind. Heating, 16,* No. 2, 252-4 (1949). Refers to the investigation of the conditions contributing to the lack of reproducibility in sieve analyses of metal powders by the National Bureau of Standards.

(1802) Uniform Tungsten Powders Made for Carbide Tools. *Steel, 124,* No. 10, 153 (1949). Control of fine W powder particle size and distribution on a commercial production basis by Sylvania Electric Products, Inc. is discussed.

(1803) Comparison of Methods for Determining Surface Area and Other Particle Size Data of Fine Powders. P. D. Blake, *J. Soc. Chem. Ind., 68,* No. 5, 138-148 (1949). Hydrometer method of particle size determination in sub-sieve range is described, and data obtained by this method as applied to a study of standard welding electrode coating powders are compared with three other known methods, namely by H. Heywood and P. S. Roller; tables, charts.

(1804) Grain Size of Powders Used for Hard Metal. H. Burden and A. Barker, *Engineering, 167,* No. 4332, 117-9 (1949). An investigation of several methods of measurement, to study variations in particle size which occur during production of hard metal, and effect of initial particle size of tungsten on properties of finished material, is reported.

(1805) Method of Examination of Sections of Fine Metal Powder Particles with Electron Microscope. L. Delisle, *Trans. Am. Inst. Mining Met. Engrs., 185,* 228-32 (1949). Technique to be applied to study of sections of metal powder particles, less than 20 microns in diameter, using replica material such as Formvar or Parlodion; work originated with study of particles of tungsten powders; several mounting materials were investigated; micrographs prove that application of electron microscope can be extended to examination of sections of particles.

(1806) Method of Examination of Sections of Fine Powder Particles with the Electron Microscope. L. Delisle, *Mikroskopie, 4,* 5-16 (1949). The article gives tests and pictures of metal powders, especially tungsten powder.

(1807) A Method of Particle Size Determination by the Microscope. V. D. Fréchette and H. I. Sephton, *Bull. Am. Ceramic Soc., 28,* 496-97 (1949). Features of the technique include dispersion of the sample in warm raw Canada balsam and classification of the particles by means of an external scale which is visible through the camera lurida.

(1808) The Scope of Particle Size Analysis and Standardization. H. Heywood, *Particle Size Analysis,* The Institute of Chem. Engrs., London, 1949, pp.14-24. The basic principles of sieving, sedimentation, elutriation and microscopic measurements are reviewed together with the advantages and limitations of each method. (Advance copy published Feb. 4, 1947 by Soc. Chem. Ind. (London), Roads & Bldg. Materials Group, pp. 1-11.)

(1809) Pore Size of Reduced Tungsten Powder. B. Kopelman and C. C. Gregg, *Trans. Am. Inst. Mining Met. Engrs., 180,* 666-671 (1949). Existence of pores of molecular size in H-reduced W powder. A method is proposed useful in detecting such pores in various materials, such as sintered products. Density

of gaseous reduced products or of sintered material in a liquid of large molecular volume is a better criterion for the density, as determined in water.

(1810) Contribution to the Metallographic Measurement of Particle Size. H. Kostron, *Arch. Metallkunde, 3,* No. 6, 193-203 (1949). The problem of the measurement; distribution of the different particle sizes on the surface of the slide; importance of straying.

(1811) Some Problems of Powder Metallurgy Solved by Microscope. G. C. Kuczynski and I. N. Zavarine, *Mikroskopie, 4,* 193-201 (1949). Investigation of the occurrence of sintering by microstructures of powder particles.

(1812) Methods of Determining Particle Size and Specific Surface Areas of Tungsten and Tungsten Carbide Powders. G. S. Kreimer, M. R. Vachovskaya, O. S. Safonova and E. E. Bogino, *Zavodskaya Lab., 15,* 159-67 (1949). The methods studied were: *(1)* methylene blue adsorption, *(2)* oxidation with nitric acid, *(3)* decomposition of hydrogen peroxide, and *(4)* measurement of shrinkage due to sintering.

(1813) Improved Mount for Powdered Specimens Used on Geiger Counter X-Ray Spectrometer. G. L. McCreery, *J. Am. Ceramic Soc., 32,* No. 4, 141-6 (1949). Preparation of powdered specimens to achieve high degree of random orientation and improved uniformity is described and illustrated; patterns obtained on some commonly encountered ceramic minerals are included.

(1814) A Note on the Examination of Metal Powders by Electron Microscope. J. I. Morley, Inst. Metals, Monograph No. 8, 121-125, 1949. Several electron micrographs show the effect of prolonged ball-milling on particle size of W powder. Limited deductions as to shape of particles could be drawn, when gold-shadowing was employed.

(1815) Particle Size Measurement in Radio Industry. M. L. Smith, *Particle Size Analysis,* The Institute of Chem. Engrs., London, 1949, pp. 96-103. Particle size analysis is extremely important for obtaining uniform products. Methods used for refractory metal powders and powders of Fe, Ni, Co and Al, as well as for gas absorbing and conducting powders are discussed. (Advance copy published Feb. 4, 1947, by Soc. Chem. Ind. (London), Roads & Bldg. Materials Group, pp. 77-84.)

(1816) Particle Size Distribution of Tungsten and Molybdenum Powders. A. D. Power and I. N. Kakascik, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chap. 19, pp. 311-319. Application of this new method of particle size distribution to tungsten powder is illustrated.

B. Other physical properties of powders and particles

(1817) Particle Size and Volume of Powders. H. Wolff, *Farben-Ztg., 32,* 1667-69 (1927). A discussion of the tap density as a measure of the powder pack volume is given.

(1818) Method of Determining the Thermal Conductivity of Pulverized Substances at High Temperatures. M. Pirani and G. v. Wangenheim, *Z. tech. Physik., 10,* 413-24 (1929). Tests made on quartz, Carborundum, etc. Temperature tests made with optical and thermocouple instruments. Large particles were found to have higher heat content.

(1819) Specific Gravity of Powders and Its Determination by Means of a New Kind of Voluminometer (in Russian). V. G. Gurevich and U. P. Vendt, *J. Gen. Chem. (U. S. S. R.), 2,* 555-68 (1932). A pressure voluminometer using kerosene instead of water.

(1820) E. A. Guggenheim, *Modern Thermodynamics by the Methods of Willard Gibbs.* Methuen, London, 1932. On p. 160 it is stated that calculation of the surface energy of powder particles can be made from the shape of the metal surfaces and the crystallographic orientation.

(1821) The Specific Gravity of Powders. E. J. Dunn, Jr., *India Rubber J., 85,* 662-664 (1933). A rapid method of determination described.

(1822) Apparent Density, Tap Density, and Sedimentary Volume as Measures of Fine Size Products. H. W. Gonell, *Chem. Fabrik, 6,* 77-81 (1933). The determination of bulk weight and packed weight; apparatus for shaking. Importance and use of the sedimentary volume.

(1823) Conduction of Heat in Powders. W. G. Kannuluik and L. H. Martin, *Proc. Roy. Soc. (London), A141,* 144-58 (1933). A hot wire method for determining the thermal conductivity of various powders (glass spheres, Pb_2NH, MgO, and 4 grades of Carborundum) in gases (air, H_2, CO_2, and He) at pressures from 0.5 to 76 cm. Hg is described.

(1824) Experimental Determination of Void Content of Close-Packed Mineral Powders. C. U. Pittman, L. A. H. Baum and R. N. Traxler, *Ind. Eng. Chem., Anal. Ed., 5,* 165-168 (1933). Particle size has little effect on void content (packing), texture having somewhat more; regularity of particles has the most.

(1825) X-Ray Examination of Certain Copper-Zinc Alloys at Elevated Temperatures. E. A. Owen and L. Pickup, *Proc. Roy. Soc. (London), A145,* No. 854, 258-67 (1934). The sample in form of fine filings on a thin foil is held against the camera frame by a thin sheet of copper-foil.

(1826) An X-Ray Investigation of the Lattice Distortions Produced in Cu by Filing. G. W. Brindley and F. W. Spiers, *Proc. Leeds Phil. Lit. Soc., 3,* 4-11 (1935). An investigation of the atomic scattering factor of Cu has shown that different results are obtained with Cu-powder prepared from different methods.

(1827) An X-Ray Investigation of Lattice Distortion in a Copper-Beryllium Alloy. G. W. Brindley and F. W. Spiers, *Phil. Mag., 7th Ser. 20,* No. 13, 893-902 (1935). The intensities of x-ray reflections from powdered alloy were compared with the reflections from pure Cu-powder, obtained by chemical precipitation.

(1828) A Simple Apparatus for Determining the Electrokinetic Potential of Powdered Substances (in Russian). V. M. Gortikov, *Colloid J. (U. S. S. R.), 1,* 233-8 (1935). Electroosmotic method.

(1829) An X-ray Examination of Lattice Distortion in Cu and Ni Powders. G. W. Brindley and F. W. Spiers, *Phil. Mag., 7th ser., 20,* No. 136, 882-93 (1935). Chemically prepared powders; filed powders from chill-cast copper rod; filed powders from a hard drawn copper wire are used.

(1830) Permeability of Compacted Powder. R. N. Traxler and L. A. H. Baum, *Physics, 7,* No. 1, 9-14 (1936). The determination of the average pore size is described.

(1831) Method for the Production and Measuring of Metal Single Crystals Between 20 μ and 0.2 μ. A. Goetz and J. Rinehart, *Phys. Rev., 51,* No. 2, 147-148 (1937). A new method to measure the dependence of electromagnetic properties of metal crystals upon their size. The metal is sprayed while liquid.

(1832) Investigation of the Dispersion of X-Rays by Copper (in Russian). B. M. Rovinskii, *J. Exptl. Theoret. Phys. (U. S. S. R.), 7,* 971-7 (1937). Copper powder and mixture of Cu with Al powder are tested.

(1833) N. K. Adam, *The Physics and Chemistry of Surfaces.* Oxford Univ. Press, 1938, 402 pp. It is stated on p. 232 that in the empty space between the contacting areas of metallic surfaces, the shape of the surfaces and the crystallographic orientation permit the calculation of the surface energy. Applies to powder particles.

(1834) A Measuring Instrument for the Rapid Determination of Magnetic Properties. F. Förster, *Z. Metallkunde, 32,* No. 6, 184-190 (1940). Description is given of a device for direct observation of the hysteresis loop and for determination of the magnetic saturation, residual induction, coercive force initial permeability, peak curve, and magnetostriction. Continuous magnetic testing and control, and testing of metal powders are discussed.

(1835) The Testing of Powdered Iron for Sintering. F. Eisenkolb, *Die Abnahme, 6,* 73-76 (1943). The maximum compacting pressure at which the powder pressing

still collapses upon removal from the die is taken as a criterion, and other properties of the powder are related to this characteristic.

(1836) Activities of Subcommittees. Committee B-9 on Metal Powders and Metal Powder Products. *Proc. Am. Soc. Test. Materials, 44,* 292 (1944). Testing methods outlined. Personnel of committee B-9 listed.

(1837) Magnetic Measurement on Fe-powders. T. Oddie, *J. Sci. Instruments, 21,* No. 9, 154 (1944). Measured results are given for the permeability and the magnetic loss coefficient of carbonyl iron and H reduced iron powders. The method is described for testing cylindrical cores without air-gaps in the magnetic circuit.

(1838) Geiger Counter Spectrometer for Industrial Research. H. Friedman, *Electronics, 18,* No. 4, 132-7 (1945). New instrument measures x-ray intensity and diffraction angles of powdered chemical and metallurgical samples directly and speedily.

(1839) Tentative Method for Determination of Flow Rate of Metal Powders. Metal Powder Association. M.P.A. Standard 3-45T, 1945, 3 pp. Describes the apparatus and procedure used in the determination of the flow rate of metal powders. It is suitable only for those powders which will flow unaided through the specified apparatus.

(1840) Tentative Method for Determination of Apparent Density of Metal Powders. Metal Powder Association. M.P.A. Standard 4-45T, 1945; 2 pp. Describes the procedures and apparatus used in the determination of apparent density of free flowing metal powders as defined in M.P.A. Standard 3-45T.

(1841) Apparent Density of Metal Powders. *A.S.T.M. Standards, Pt. I-B,* 728 (1946). Apparatus for testing free-flowing metal powders is described.

(1842) Committee B-9 on Metal Powder and Metal Powder Products. *Proc. Am. Soc. Test. Materials, 46,* 268-280 (1946). Recommendations affecting standards; activities of sub-committees; tests for flow of metal powders, for sieve analysis of granular metal powders, and for apparent density; methods of sampling.

(1843) Geiger Counter Used in Powder Metallurgy. E. S. Kopecki, *Iron Age, 157,* No. 9, 48-51 (1946). Use of x-ray spectrometer in powdered metals.

(1844) Determination of the Density of Fine Powder. W. R. Ruby and R. P. Loveland, *J. Phys. Chem., 50,* No. 4, 345-63 (1946). Glass pycnometer, filling apparatus and tests are described.

(1845) Analysis of Mixed Powders with Geiger Counter. Z. W. Wilchinsky, *J. Applied Phys., 18,* 929 (1947). Outlines simple technique to measure diffracted x-ray intensities for several samples in succession.

(1846) Compressibility Factor for Metal Powders. C. B. Smith, *Proc. Fourth Ann. Spring Meeting Met. Powd. Assoc.,* pp. 29-35. Chicago, Apr. 15-16, 1948. Development of a formula for evaluating compressibility whose results, compared with experimental data, were surprisingly close. Fe and Cu examples are given.

(1847) A Tumbling Test for Pressed Pellets. A. Stewart, *J. Sci. Instruments, 25,* 438-40 (1948). The compressed cylindrical pellets are tumbled in a cylinder of glass; for any length of the tube there is a speed of rotation at which the loss in weight is a maximum, and this moves to lower speeds as the tube length increases. Purpose of test is an appraisal of the compactibility and green strength of the powder.

(1848) Compressibility Test for Metal Powders. F. V. Lenel, *Bull. Am. Soc. Test. Materials,* No. 158, 52-6 (1949). Report on study of influence of various lubricants upon compressibility in cooperative test program; five methods of lubrication compared, *i. e.,* lubrication of die barrel with SAE 30 oil, oleic acid, pump grease, and dispersion of colloidal graphite, and lubrication by mixing powder with solid lubricant and compacting it in nonlubricated die; tabular data are presented.

(1849) Determination of Green Strength by Transverse Rupture. J. P. Scanlan and R. P. Seelig, *Powd. Met. Bull., 4,* No. 4, 128-32 (1949). Methods of evaluating different powders and different molding conditions with respect to

resulting green strength reviewed; as result of recent investigation by authors transverse rupture test was found most reliable and simple; examples presented showing its usefulness; tables.

C. Chemical properties of powders

(1850) Hydrogen Reduction of Iron. A. Ledebur, *Stahl u. Eisen, 2,* 193-97 (1882). The oxygen content in iron is determined by hydrogen reduction at high temperature after evacuation.

(1851) Method of Determining Value of Zinc Dust. H. N. Morse, *Am. Chem. J., 7,* 52-57 (1885). An apparatus is described in which the acid is allowed to act for some time upon Zn dust before the heat is applied, so that the finer material may be slowly and quietly dissolved.

(1852) Iodimetric Studies. G. Topf, *Z. anal. Chem., 26,* 277-302 (1887). Iodine in neutral solution is mixed with Zn dust in excess to form a Zn iodide.

(1853) Determination of Value of Zinc Dust. G. Klemp, *Z. anal. Chem., 29,* 253-66 (1890). By using a solution of potassium iodide in acid.

(1854) Method and Apparatus for Determination of Zinc Dust. F. Meyer, *Z. angew. Chem., 7,* 231, 435 (1894). By the action of dilute hydrochloric acid on metallic Zn in Zn dust, the H content is burned by Cu oxide and the water formed is weighted.

(1855) Analysis of Zinc Dust. *Mining Sci. Press, 103,* 356 (1902). The Drewson method is based upon the fact that finely divided Zn reduces a solution of chromic acid without generating H.

(1856) Analysis of Calcium Carbide Sodium Amalgam and Zinc Dust With the "Decomposition Flask". E. Berl and A. W. Jurissen, *Z. angew. Chemie, 23,* No. 6, 248-9 (1910). Zn dust was analyzed in a decomposition flask filled with carbon dioxide and a drop of platinum chloride was added.

(1857) Zinc Dust Tests. W. J. Sharwood, *Chem. Met. Mining Soc. S. Africa, 12,* 332-8 (1912). Estimation of Zn oxide in Zn dust. The method is based on the solubility of Zn oxide in ammonium chloride and ammonia. Determination of Zn in dust.

(1858) Notes on Analysis of Zinc Dust. J. E. Clennell, *Eng. Mining J., 95,* 793, 1108 (1913). Description of the most acceptable methods for determining the constituents of Zn dust, used for cyanide solution, is given.

(1859) Powder Analysis Method. C. M. Johnson, *Met. Chem. Eng., 13,* No. 1, 17 (1915). Electric muffle furnace for the determination of C and O in tungsten powder.

(1860) Zinc-Dust Analysis. *Eng. Mining J., 106,* No. 3, 145-146 (1918). Description of the Franz Meyer method of estimating the Zn content in Zn dust. Bibliography.

(1861) Investigation of Oxygen in Iron. P. Oberhoffer, *Stahl u. Eisen, 38,* 105-110 (1918). The oxygen content in iron is determined by hydrogen reduction at high temperatures.

(1862) New Method of Estimating Zinc in Zinc Dust. L. A. Wilson, *Eng. Mining J., 106,* 334-335 (1918). The importance of maintaining solutions saturated with hydrogen and minimizing temperature variations is emphasized. The arrangement eliminates sources of error and decreases the time for the analysis.

(1863) Notes on the Estimation of Metallic Zinc Content of Zinc Dust. W. F. Edwards, *Chem. Met. Eng., 21,* 192 (1919). The amalgam method and the ferric ammonium method are discussed. Results are compared.

(1864) Investigation of Oxygen in Iron. P. Oberhoffer and O. von Keil, *Stahl u. Eisen, 40,* 812-814 (1920). The hydrogen loss method of determining the oxygen content in iron is described.

(1865) A New Method for Evaluating Zn-Dust. D. Bullenheimer, *Metall u. Erz, 18,* 443-6 (1921). A new method: mixing of hydrogen peroxide and sulfuric acid may dissolve quickly zinc dust, and without generation of gases. Potassium permanganate is a reagert for content of hydrogen peroxide.

(1866) Estimation of Aluminum in Tungsten. V. Froboese, *Analyst, 47,* 225 (1922); *Z. anal. Chem., 61,* 107-110 (1922). An analytical method for the determination of aluminum in tungsten is presented.

(1867) Determination of Molybdenum in Tungsten. D. Hall, *J. Am. Chem. Soc., 44,* 1462-65 (1922). An analytical method for the determination is given.

(1868) Testing Zinc Dust for Textile Purposes. J. M. Matthews, *Color Trade J., 10,* 220 (1922). Testing solution contains 40 g. potassium bichromate in one liter of water, 200 g. ferrous sulfate in one liter of a 10% solution of sulfuric acid.

(1869) Determination of Small Quantities of Molybdenum in Tungsten. W. King, *J. Ind. Eng. Chem., 15,* 350-54 (1923). A quantitative determination of Mo in the presence of W is presented; a calorimeter used for the analysis is described.

(1870) A New Method of Micro-Gas Analysis. L. Reeve, *J. Chem. Soc., 125,* 1946-54 (1924). The determination of total carbon in tungsten is described.

(1871) Determination of Boron in Tungsten. D. H. Brophy, *J. Am. Chem. Soc., 47,* 1856-61 (1925). A method for the determination of small quantities of boron in tungsten is presented.

(1872) Volumetric Determination of Carbon in Tungsten by Combustion. W. King, *J. Am. Chem. Soc., 47,* 615-16 (1925). An apparatus for the determination of total carbon in tungsten is described.

(1873) Determination of Insoluble Oxides in Iron and Steel. R. Wasmuth and P. Oberhoffer, *Arch. Eisenhüttenwesen, 2,* 829-42 (1928-29). Oxygen and insoluble oxides such as alumina or silica are determined in iron or steel by passing chlorine over the latter, thereby forming ferric chloride which volatilizes at 315° C. (600° F.) and permits separation of the oxide residue.

(1874) The Oxygen Content in Iron Alloys. H. Peterson, *Arch. Eisenhüttenwesen, 3,* 459-472 (1929/30). The oxygen content in steels containing above 0.2% C is determined by a method which passes the carbon oxide-containing gaseous reaction product over a catalyst that decomposes it into methane and water, and permits absorption and weighing of these components.

(1875) Practical Method for Determining the Purity of Powdered Metals Used Commercially. P. Galimberti, *Ann. chim. applicata, 22,* 497-500 (1932). An apparatus is described for purity determinations of metal powders. A weighed amount of the metal is mixed with water, HCl is siphoned onto the mixture, and the evolved H_2 measured. The weight of pure metal is calculated from the weight of H_2 evolved.

(1876) Composition of Metallurgical Powders and Methods of Removing Non-Ferrous Metals from Them (in Russian). I. M. Dubrovin, *Uralskii Gosudarst, Manch. -issledovatel Inst. Zvetnym Metal Sbornik Manch Issledovatel Rabot, 1,* 25-56 (1935). Chemical properties and analytical work is described.

(1877) A New Vacuum Furnace for the Determination of Oxygen in Steel. G. Thanheiser and E. Brauns, *Arch. Eisenhüttenwesen, 9,* 435-39 (1935/36). A process of hot extraction of oxygen during the analysis of iron and steel is described. A CO-CO_2-containing gas mixture is formed in a vacuum furnace at 1600-2000° C. (2900-3600° F.). The gas mixture can be separated and its components determined by microgas analysis.

(1878) Transmission Coefficient for Hydrogen on Metals. W. Baukloh and H. Guthmann, *Z. Metallkunde, 28,* 34-40 (1936). A description is given of an apparatus and tests for the permeability of metals and the decarburization mechanism, with emphasis being placed on iron and steels, subjected to annealing and heat treatments under various atmospheres.

(1879) Determination of Ferrous and Ferric Oxide in Sponge Iron. N. Stognii, *Zavodskaya Laboratoriya, 8,* 391-5 (1939). Experimental study is reported of the Wilner-Merck method for determining and separating metallic iron from oxides.

Reduction of trivalent Fe by metallic Hg and removal of latter by sublimation is described. Author's new simple procedure for separate determination of oxides of iron in presence of metallic iron is given.

(1880) The Vacuum Fusion and Vacuum Heating Methods. H. A. Sloman, *J. Iron Steel Inst., 143,* No. I, 298-312 (1941). The determination of oxygen, nitrogen, and hydrogen in steel is investigated.

(1881) Residue Analysis by Cuproammonium Chloride Method. F. Willems, *Stahl u. Eisen, 61,* 423 (1941). Need for a simple rapid method for determining the nonmetallic constituents in iron powders.

(1882) Spectroanalysis of Molybdenum and Tungsten in Ores. C. G. Carlsson, *Jernkontorets Ann., 127,* No. 11, 572-82 (1943). Particulars are given on a method of spectroanalysis of ores for low Mo and W contents. Under most favorable conditions of analysis, accuracy is ± 0.01%, and time required is 30 minutes.

(1883) Determination of MoO_3 in Mo Powder. Action of NH_3 on Mo. F. Pavelka, A. Laghi and A. Zucchelli, *Mikrochemie ver. Mikrochim. Acta, 31,* 97-101 (1943). New method to determine oxide content in Mo powder obtained by reduction of NH_4 molybdate with H.

(1884) Determination of Oxygen. H. A. Sloman, *J. Iron Steel Inst., 148,* No. II, 235-38 (1943). Further investigations by the vacuum fusion method of oxygen in iron and steel are reported.

(1885) Sponge Iron. J. P. Morris, *U. S. Bur. Mines, Rept. Invest., 3824,* (1945). In presence of only metallic Fe and Fe oxides and with -65 mesh samples the $HgCl_2$ method gives accurate results for determining metallic iron and oxygen in sponge iron.

(1886) The Application of the Vacuum-Fusion Method to the Determination of the Oxygen, Hydrogen and Nitrogen Content of Non-Ferrous Metals, Alloys and Powders. H. A. Sloman, *J. Inst. Metals, 71,* 391-414 (1945). Vacuum fusion is used for the determination of gases in metallic powders.

(1887) Determination of Nitrogen in Refractory Metal Carbides and Their Compositions. J. C. Redmond, L. Gerst and W. O. Touhey, *Ind. Eng. Chem., Anal. Ed., 18,* No. 10, 24-26 (1946). Procedure and distillation apparatus described for determination of N in W, Ti and other cemented refractory metal carbides and nitrides for cutting tools and dies.

(1888) Spectrographic Analysis of Several Powdered Al alloys. N. K. Rudnevsky, *Zavodskaya Lab., 12,* No. 2, 189-193 (1946) (in Russian); *Met. Abstracts, 13,* 427 (1946). Conditions are given for the analysis of alloys containing 4.5-6% Si, 6.25-7.75% Cu, <1.5% Fe, <0.5% each of Mg, Mn and Zn, balance Al.

(1889) The Determination of Small Quantities of Silica, Alumina, and Lime in Tungsten Carbide Powder. C. E. A. Shanahan, *Analyst, 70,* 421-23 (1946). Author has experimented with the known methods of determining silica or thoria in W, involving the separation of W by volatilization as chlorides.

(1890) Determination of Nitrogen in Titanium Carbide and Hard Metals. W. Dawihl and Studiengesellschaft Hartmetall. F. D. Rept. No. 3745/47(1947). A chlorine method of determining the N content was developed and reported in 1938.

(1891) Analysis with X-Ray Spectrometer. J. C. Redmond, *Anal. Chem., 19,* No. 10, 773-77 (1947). Quantitative analysis of mixtures of heavy metal carbides.

(1892) Metal Oxides in Magnesium Powder. B. S. Srikantan *J. Indian Chem. Soc., Ind. & News Ed., 10,* 139-140; *C. A., 43,* 982 (1947). Analysis of samples of Mg powder are taken by the method of coning and quartering varied by as much as 50% of powder, separated into different sizes by screening; the results with grains up to 40 mesh were reproducible, but finer dust (-200 mesh) gave results differing by 2%.

(1893) Composition of Boron Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3756/47 (1947). Description of complete analysis of a series of boron carbides, dating from 1940.

(1894) Carbide Dust. Studiengesellschaft Hartmetall. F. D. Rept. No. 3826/47 (1947). Analysis of samples of cooling water for WC dust, were reported in 1939.

(1895) Grinding Dust. Studiengesellschaft Hartmetall. F. D. Rept. No. 3942/47 (1947). Testing of grinding dust for tungsten content is described in a report of 1943.

(1896) Determination of Nitrogen in Titanium Carbide and Hard Metals. *Met. Powd. Rept., 2,* No. 9, 136-137 (1948). Ref. to Studiengesellschaft Hartmetall Oct. 1938; B.O.T. Ger. Div. F.D. 3745/47. As an alternative to the Dumas method a chlorine method was developed, which required less apparatus, but had the inconvenience of working with chlorine.

(1897) Analysis of Simple and Complex Tungsten Carbide. J. J. Furey and T. R. Cunningham, *Ind. Eng. Chem., Anal. Ed., 20,* 563-70 (1948). Details of analytical methods are given.

(1898) Application of Micro-Analytic Methods on Powder Metallurgy. H. Malissa and H. Spitzy, *Oesterr. Chem. Ztg., 49,* No. 10/11, 187 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 54. The authors give some references of using micro-analytic methods for the solution of powder metallurgy problems. Combined macro- and micro-analytic methods for the analysis of the carbon content. Micro-method of determination of metals such as Mo, W, Ti, Ni and Fe.

(1899) Tentative Method for Determination of Hydrogen Loss of Metal Powders. Metal Powder Association. M.P.A. Standard 2-48T, 1948, 4 pp. Describes method and apparatus for the determination of the approximate oxygen content of some metal powders, giving the limitations of the method.

(1900) Tentative Method for Determination of Insoluble Matter in Iron and Copper Powders. Metal Powder Association. M.P.A. Standard 6-48T, 1948, 3 pp. Describes the equipment and procedure used in the chemical analysis of iron and copper powders for insoluble matter. The method is designed also to test those powders with a high silicon or silica content and differentiate between total insolubles and insolubles other than silica.

(1901) Method of Oxygen Determination in Powders of Soft Iron and Steel. G. Naeser, *Met. Powd. Rept., 2,* No. 12, 191 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 188 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 5b. Routine testing of iron powders for oxygen content is carried out in an apparatus which consists of a vertical Carborundum resistance furnace with a refractory tube. The apparatus is filled with N, not to be renewed, if the CO formed is removed by raising the leveling vessel after test.

(1902) Rapid Spectographic Analysis of Cemented Carbide Compositions. J. C. Redmond, *Steel, 122,* No. 26, 86-88 (1948). Analytical methods applied to the carbide powders are described.

(1903) Analysis of Cemented Carbide Compositions. W. O. Touhey and J. C. Redmond, *Anal. Chem., 20,* 202 (1948). Analytical methods applied to the carbide powders are described.

(1904) Determination of Zinc Oxide as Residual of Zinc Powder. E. W. Balis, L. B. Bronk and H. A. Liebhafsky, *Anal. Chem., 21,* 1373-74 (1949). Zn powder is placed in a Cu boat, encased in Cu foil and heated; Zn diffuses into Cu, the residual Zn oxide being brushed off and weighed on the micro-balance.

(1905) A Calculator for Use in Evaluation of Metal Powders by Nitrometer Method. R. J. Cole, *Chemistry & Industry, 1949,* No. 41, 703. A slide rule used for calculating the free metal content in Mg and Al powders by attaching the sample with acid and measuring hydrogen by evolution test.

(1906) Tentative Methods for Determination of Iron Content of Iron Powder. Metal Powder Association. M.P.A. Standard 7-49T, 1949, 4 pp. Describes the procedures for the chemical analysis of granular iron powder to determine *(1)* the total iron content, *(2)* the metallic iron content, *(3)* the ferric and ferrous oxide content.

(1907) New Method of Oxygen Determination in Powders of Soft Iron, Steel, and Some Other Metals. G. Naeser, *Stahl u. Eisen, 69,* No. 1, 19-21 (1949). Development of a new volumetric method for oxygen in iron, particularly for analysis of carbon-containing iron powders, is reported. Description of apparatus and procedure is given. Effect of temperature on rate of reaction, and reduction of different pure oxides as a function of time, are discussed.

(1908) Determination of Metallic Iron in Powders. M. Portessis, *Compt. rend., 228,* 1233-34 (1949). Powdering hard minerals, like corundum and diaspore, in an iron mortar, contaminates the powder with Fe. The Fe content can be calculated from the volume of H_2 liberated upon treating a weighed sample of powder with HCl.

(1909) Determination of Metallic Iron and Iron Oxide. H. U. von Vogel, *Arch. Eisenhüttenwesen, 20,* 287-92 (1949). The methods for the investigation of mixtures of iron and iron oxide are referred to. Tests were made on samples taken from production.

3. Powder Processing Methods and Equipment

1. POWDER CONDITIONING TREATMENTS

(separating, classifying, combining, deformation, heat treating, cleaning, collecting, feeding and conveying)

(1910) **Automatic Zinc Dust Feeding.** A. W. Morris, *Mining Sci. Press, 104,* 249-50 (1902). The feeder in use on a mine in Mexico is described.

(1911) **Improved Zinc Feeder.** A. J. Clark, *Eng. Mining J., 109,* 862 (1920). A feeder for zinc dust is illustrated and described.

(1912) **Manufacture and Use of Silver-Bronze Powders.** L. J. Mitchell, *Metal Cleaning Finishing, 8,* 345-6 (1912). The difficulty of mixing heavy powders such as Cu or Au with light powders such as Al has been overcome by using different polishing oils on the powders, and by a new process which assures a uniform mixing.

(1913) **Pure Metals.** A. E. van Arkel, *Reine Metalle.* Springer, Berlin, 1939. Methods of reduction; methods for purification; purifying tests. Special part for the individual metals. Includes refractory and rare metals.

(1914) **Electrostatic Separation of Solids.** F. Fraas and O. C. Ralston, *Ind. Eng. Chem., Ind. Ed., 32,* 600 (1940). Electrostatic separators are classified according to the electric property of the solid. Only the conductance method has been applied.

(1915) **Mixing by Ball Milling. (in English)** Y. Oyama, *Sci. Papers Inst. Phys. Chem. Research (Tokyo), 37,* 17-29 (1940). Mixing of 2 sizes by ball mill motion. Maximum mixing at 60 r.p.m. Horizontal oscillation method more effective.

(1916) **Separation of Fe-Ni Powder by Air.** Yu. Butt and L. A. Plotnikov, *Zavodskaya Lab., 10,* 650-1 (1941). Apparatus for separation of Fe-Ni powders into uniform size fractions.

(1917) **Evacuation of Metal Powders.** C. Hardy, *Metal Ind. (London), 60,* No. 17, 288-9 (1942). Brief commentary on powder treatment.

(1918) **Influence of "A"-Film Treatment on the Characteristics of Three Types of Iron Powder.** A. M. Burghardt and E. M. Rubino, *Watertown Arsenal Lab. Rept. WAL 671/34* (1945); U. S. Dept. Comm., PB. 39590; *Met. Powd. Rept., 2,* No. 3, 41-47 (1947). Experimentation with methylchlorsilane vapors (*cf.* A. Squire, Watertown Arsenal Lab. Rept. WAL 671/25) are continued with hydrogen-

reduced, electrolytic and carbonyl iron powders. Powder characteristics considered were chemical analysis, chemical stability, and flow rate; and apparent density; green and sintered compacts were tested, and tensile strength values established; it was found that the "A"-treatment did not alter the latter in hydrogen-reduced and carbonyl specimens.

(1919) Influence of "A" Treatment on the Characteristics of Finely Divided Iron Powder. A. Squire, Watertown Arsenal Lab. Rep. WAL 671/25, June 1, 1945, 11 pp.; *Met. Powd. Rept., 2,* No. 3, 38-41 (1947). A sample of -325 mesh H-reduced iron powder was subjected to a treatment with methyl chlorsilanes vapor. "A"-tests showed that the dry-film "A" was not present in sufficient quantity for an effect on diffusion or bonding; however, flow rates were considerably improved.

(1920) Treatment of Non-Flowable Iron Powder. *Machine Design, 18,* No. 11, 98; *Met. Powd. Rept., 1,* No. 6, 83 (1946). Results of tests on very fine iron powder at Watertown Arsenal Lab.

(1921) Paste and Powder Mixing. D. F. Riley, *Mfg. Chemist, 17,* No. 11, 489-494 (1946). In the course of a description which contains also a brief section on theory of powder mixing, the author mentions the double cone mixer which operates without moving agitator blades.

(1922) Screening Materials. W. O. Carby, *Brit. Eng. Export J., 30,* No. 28, 977-80 (1947). Screening and classifying machines for refractories and metal powders are described.

(1923) Prevention of Shrinkage of Iron Powder. F. von Griesewald, F. D. Doc. No. 1765/46, 1947, 4 pp.; *Met. Powd. Rept., 1,* No. 5, 69 (1947). Chemically produced iron powder gives rise to serious shrinkage and distortion during sintering, presumably owing to its inherent porosity. But when the powder was rolled into a strip of 1 mm. thickness, and several thicknesses were then rolled a second time, and these composite strips then pulverized, compacts made thereof showed a shrinkage of less than 1%.

(1924) Vibrator Mill for Metal Powder. Siebtechnik G.m.b.H., F. D. Rept. No. 248/47 (1947). Contains five drawings, dated 1943-46, of Vibratom mills of different capacities. Mills especially suitable in grinding carbides.

(1925) Sieving Machines. Studiengesellschaft Hartmetall. F. D. Rept. No. 3751/47 (1947). The usual sieving machines produce agglomeration of the carbide powder and consequently loss of output. An improvement was effected in 1936 by designing a special vibrating machine with a superimposed cam action. Diagrams.

(1926) Grinding Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3757/47 (1947). Results were reported in 1936 of a grinding test with tungsten carbide in a large ball mill, 400 mm. diameter and 450 mm. long.

(1927) Carbide Powder Treatment. Studiengesellschaft Hartmetall. F. D. Rept. No. 3758/47 (1947). In 1937 it was reported that acetone could be quantitatively removed from a ball-milled charge of carbide powder by means of centrifuging and was fit for recycling. Charges moistened with water could not be so treated.

(1928) Mixing and Kneading Machines. Studiengesellschaft Hartmetall. F. D. Rept. No. 3767/47 (1947). Favorable report, dating from 1936, on various mixing and kneading machines made in Germany by Eirich, Hardheim; Draiswerke, Mannheim; and Werner and Pfleiderer, Stuttgart.

(1929) Ball-Milling. Studiengesellschaft Hartmetall. F. D. Rept. No. 3772/47 (1947). This report of 1937 shows that the iron content from ball-milling is mainly due to the action of the carbide. Low iron-bearing carbides can, therefore, be made by ball-milling only the cobalt powder and then adding the carbide.

(1930) Ball-Milling of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3774/47 (1947). With prolonged ball-milling, pure tungsten carbide begins to blister at increasingly lower sintering temperatures after reaching maximum density. This was presumed in this report of 1937 to be due to surface effects through formation of hydrocarbons during ball-milling.

(1931) Ball-Milling of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3775/47 (1947). According to this report of 1937, for WC-TiC tips, it is not necessary to ball-mill the WC, but only the TiC and the Co.

(1932) Ball-Milling of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3788/47 (1947). X-ray investigations of the carbide ball-milling process in 1937-38 proved that *(1)* cobalt diffuses into the carbide and is not adsorbed, *(2)* only the cobalt is drastically comminuted and not the carbide, *(3)* prolonged ball-milling (up to 980 hours) reduces also the carbide particles, and *(4)* tips made of ball-milled cobalt mixed with non-ball-milled carbide were equivalent to normal ball-milled WC-Co mixtures.

(1933) Ball Milling of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3794/47 (1947). According to this report of 1938, dry ball-milling of WC produces severe distortion of the x-ray lines compared with none for wet ball-milling, and considerable size reduction occurs. The cutting performance of tips from dry-ball-milled WC powder, with 3% Co, was equivalent to that of normal 95/5 tips, and superior to that of wet-milled WC with 3% Co. Dry ball-milled WC was thought to have a particle size of 0.1 micron.

(1934) Centrifugal Mill. Studiengesellschaft Hartmetall. F. D. Rept. No. 3797/47 (1947). Satisfactory results were obtained in 1938 with the Raupach centrifugal mill on carburized scheelite.

(1935) Milling of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3807/47 (1947). According to this report of 1939, carbide scrap should be ground in a centrifugal mill prior to fine ball-milling.

(1936) Grinding of Hard Metal Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3832/47 (1947). A general summary of experience on grinding of hard metal powders, *e. g.*, different powders, wet or dry grinding, cobalt, the vibration mill, ball-milling, suggestions for further research, is given in this report, dating from 1940.

(1937) Part 2. Effect of Mixing of Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3913/47 (1947). Poor solubility observed in WC-TiC tips may be due to insufficient mixing of the powders. More severe ball-milling may be required according to this report of 1942.

(1938) Ball Milling of Mixtures. Studiengesellschaft Hartmetall. F. D. Rept. No. 3929/47 (1947). According to this report of 1944, prolonged ball-milling of $Fe\text{-}TiO_2$, $Fe\text{-}Cr_2O_3$, $Fe\text{-}MnO_2$ mixtures has a bad effect upon the compacting properties.

(1939) Part 1. Effect of Grinding Methods on Sintered Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3943/47 (1947). Correlation of grinding method (wet or dry) and grinding time with grain size and phase composition of the sintered carbide is given in this report dating back to 1942-3. Effect of grinding conditions of the WC upon the formation of WC-TiC solid solutions.

(1939A) Part 3. Ball-Milling and Microstructure. Studiengesellschaft Hartmetall. F. D. Rept. No. 3943/47 (1947). According to this report of 1943, the sequence of charging constituents to the ball mill has an important effect upon the microstructure of the finished carbide, whether with WC-Co or WC-TiC-Co.

(1940) Sieving and Grading. *Machinery Lloyd, 20,* No. 11, 91 (1948). A brief illustrated description of a sieving machine made by S. N. Bridges & Co., Ltd.

(1941) Latest Methods for Cleaning Aluminum Powder. S. H. Phillips, *Automotive Ind., 98,* No. 2, 42 (1948). Solvent wipe-on cleaning, vapor degreasing, emulsion cleaning, acid cleaning are discussed.

(1942) Grinding in very Small Containers and Influence of Grinding Liquid in Vibration Mill. F. Skaupy and R. Herrmann, *Met. Powd. Rept., 3,* No. 1, 12 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 180 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 8b, 8c. Calculated surface areas on 50 g. iron powder, originally minus 36 plus 60 B.S. mesh, ground for 20 hours, differed widely with the grinding liquid.

(1943) Design and Operation of Small Mills for Mixing Powder. D. Summers-Smith, *Metallurgia, 39,* No. 234, 309-11 (1949). Two sizes of ball mills are described, which have been designed to facilitate metallurgical research by powder metallurgy methods, the larger being suitable for mixing samples weighing about 10 g., and the smaller one for dealing with samples of about 1 g.

2. PRESSING AND BRIQUETTING

(1944) A Survey of Powder Metallurgy Processes – III. L. A. Durán, *Rev. cienc. applicada, 3,* No. 4, 255-68 (1949). Deals with compression of powders, presses and dies.

(1945) Technical Equipment for Powder Metallurgy. F. Krall, *Einführung in die Pulvermetallurgie,* Technische Hochschule Graz, 1949, pp. 55-83. Hydraulic and mechanical presses and hot-pressing apparatus are described.

A. Static pressing

(1946) Consolidation of Metal Powders. W. Spring, *Bull. classe sci., Acad. roy. Belg., 45,* 746-54 (1878). Alloys of low melting metals were obtained by pressing mixtures of metal powders at temperatures below their melting points.

(1947) Research on the Welding of Solid Bodies Induced by Pressure. W. Spring, *Bull. classe sci., Acad. roy. Belg., 49,* No. 2, 323-79 (1880). Results obtained by the use of metal powders (Bi and Sb) and metal filings (Pb, Sn, Zn, Al and Cu).

(1948) Union of Bodies by Pressure. W. Spring, *Ann. Chem. Phys., 22,* No. 5, 170-217 (1881). Pressing of Bi, Sn, Zn, Sb powders; Pb, Al and Cu filings; Pt sponge. Also used were powdered sulfites and sulfides and oxides.

(1949) Formation of Alloys Through Pressure. W. Spring, *Ber., 15,* No. 1, 595-7 (1882). Study of processes involving Wood's metal, Rose's alloy and brass made from powders or filings.

(1950) Diffusion and Compression of Metals. *Engineering, 77,* 300 (1904). Describes the research of Prof. Hof in connection with the publication of W. Spring. Hof has confined his studies to the compression of metal powders.

(1951) Working of Tungsten. W. E. John, *South African Inst. Eng., 20,* 121-29 (1922). Pressing of W powders. The bend is often due to bad pressing if the powder at top of mold tends to pack and bridge.

(1952) Molding of Metal Powders. *Can. Machinery, 43,* No. 12, 57 (1932). Production of small parts from metal powder by a molding process is discussed in a bulletin published by Arthur D. Little, Inc.

(1953) The Pressing of Metal Powders. R. P. Seelig, *Metals & Alloys, 12,* No. 6, 744-748 (1940). Pressing operation and die designs discussed and illustrated.

(1954) Briquetting of Black Metal Filings With the Help of Coal Tar and Alabaster. E. P. Babich, *Liteinoe Delo, 12,* No. 7-8, 7-10 (1941). Solidifiers and hardeners of alabaster, chalk and coal are thoroughly satisfactory and can almost completely replace the cement in the briquetting of filings.

(1955) Pressing of Metal Powder. R. P. Seelig, *Metal Ind. (London), 58,* No. 8, 182-85 (1941). A consideration of the fundamental techniques involved in the compaction of metal powders into parts of intricate shape.

(1956) Dense Powder Metallurgy Parts. R. P. Seelig, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 23, pp. 264-270. Molding of some dense machine parts of complicated shapes.

(1957) Molding of Metal Powders. J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 21, pp. 244-258. Powder considerations, aspects of die design, elementary experiments, dies for production work, shrinkage, hot-pressing.

(1958) Powder Metallurgy: Technique Suggested by Tungsten Carbide Process. H. Berry, *Wire Ind., 10,* No. 116, 361-362 (1943). The use of the minimum possible amount of paraffin-wax as a binder in pressings is discussed, with special reference to Cu-Sn.

(1959) Plastics and Plasticity. E. V. Crane, *Iron Age, 152,* 84-5 (1943). Molding of metal powders; fabricating of lubricated bushings.

(1960) E. V. Crane, *Plastic Working of Metals and Non-Metallic Materials in Presses.* 3rd ed., Wiley, New York, 1944; Chapman and Hall, London, 1944, 540 pp. Book on sheet metal working and forging has been expanded to include powdered metals and synthetic plastic powders, their pressing, and necessary presses and tools.

(1961) Presses and Processes for Metal Powder Products. E. V. Crane and A. G. Bureau, *Iron Age, 153,* No. 26, 36-41; *154,* No. 1, 62-67; *Steel, 115,* No. 4, 90-94 (1944). Making of porous products such as bushings, and compression of solid parts; problems; different kinds of presses. Principles for selection of dies and heat treatment discussed.

(1962) Presses and Processes for Metal Powder Products. E. V. Crane and A. G. Bureau, *Trans. Electrochem. Soc., 85,* 63-87 (1944). Standard methods of making wide diversity of metal powder machine parts and finished products are discussed; recommended procedures for making composite articles of metal and non-metal such as abrasive wheels.

(1963) Plastics Increase Powder Metal Flow. H. L. Strauss, Jr., *Am. Machinist, 89,* No. 20, 113 (1945). Improved flow of powdered metals in briquetting die achieved by adding approx. 5% vinyl resin by volume and employing moderate heat during compacting cycle.

(1964) Compressed Air Speeds Powder Metal Forming. *Materials & Methods, 23,* No. 3, 729 (1946). S. K. Wellman Co. uses compressed air in various processing steps.

(1965) Considerations in Designing Parts for Powder Metallurgy. J. Donahue, *Mech. Eng., 68,* No. 11, 949-52 (1946); *Eng. Dig., 8,* No. 3, 85-88 (1947). Consideration of forming sintered metal parts, with particular reference to the effects and translation of the pressure during compaction of metal powders.

(1966) Pressing Complicated Shapes from Iron Powders. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 166,* 506-19 (1946). Pressing mechanism for curved and stepped iron parts. Variable factors in molding powdered metal parts; idealized molding of uniformly dense compacts with curved faces; practical method of molding uniformly dense compacts with curved faces; practical method of molding uniformly dense compacts with offsets, steps and recesses.

(1967) Methods Used for Overcoming Certain Limitations in the Pressing of Metal Powders. R. P. Seelig, *Powd. Met. Bull., 1,* No. 4, 54-63 (1946). Feeding, molding, lubrication, and ejection are discussed.

(1968) Molding Powder Metal Parts. R. P. Seelig, *Tool & Die J., 12,* 78, 158 (1946). Several press tool design considerations are necessary to overcome certain production limitations imposed by behavior and characteristics of powdered metals.

(1969) The Pressing Operation in the Fabrication of Articles by Powder Metallurgy. R. P. Seelig and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 166,* 492-505 (1946). Density gradients in compacts; effect of raw materials on pressing in production work; press equipment; dies; summary. Discussion.

(1970)• Plastics Increase Powder Metal Flow. H. L. Strauss, Jr., *Machinist (London), 89,* No. 42, 2275 (1946). Discusses addition of vinyl-resin to powdered metals in briquetting die and heating of the die during the compaction.

(1971) Cavities in Sintered Metal. *Modern Plastics, 24,* No. 7, 144 (1947). Describes how plastic-molding cavities, difficult and costly to hob or machine, can be made by pressing metal powders over hob held in die.

(1972) **Pressing and Sintering.** J. W. Lennox, *Machinery (London), 70,* 337-344 (1947). Machinery and procedures for the forming of metal powder parts are discussed.

(1973) **Review of Literature on Pressing of Metal Powders.** R. P. Seelig, *Trans. Am. Inst. Mining. Met. Engrs., 171,* 506-534 (1947). Introduction to seminar- review and discussion of published informations of powder metal pressing at room temperature.

(1974) **Tungsten Carbide Pressing.** Studiengesellschaft Hartmetall. F. D. Rept. No. 3776/47 (1947). This report of 1937 describes how tungsten-lampblack pressings could be obtained in a Kilian tableting press by using 0.4% glycerine dissolved in methanol or 0.3% glyptal resin in acetone. Mixing was done in an Eirich mixer for 45 min.

(1975) **A Method of Compaction of Metal Powder Parts of Intricate Shape.** H. Silbereisen, *Z. Metallkunde, 40,* No. 2, 66-68 (1949). Description of functional design of a new die intended for the mass production of metal powder parts of intricate shape. Elements of die construction; mode of operation and filling, compressing, and ejecting position are considered. Performance of one of these dies in the compacting of parts of steel powder.

B. Pressing under special conditions (pressing in vacuum, at sub-normal temperatures, etc.)

(1976) **Metal Powders Compressed in Vacuum.** *Iron Age, 148,* No. 4, 37 (1941). Difficulties are overcome by evacuating the powder and the mold; the flow of the powder is improved; and the oxidation is reduced.

(1977) **Vacuum Aids the Formation of Powder Metallurgy Compacts.** C. Hardy, *Steel, 110,* No. 3, 84 (1942). A report on experimental results is given, which indicates that vacuum helps in eliminating pressing laminations.

(1978) **Metal Powders Pressed at Low Temperature.** H. W. Jones, *Light Metals, 5,* No. 51, 95-107 (1942). Cu, Fe, Al-Cu alloys were pressed at various pressures at room temperature, at -80° C. (-112° F.), and -193° C. (-315° F.). Density and Brinell hardness were determined, and found slightly lower, the lower the pressing temperature, and the less the pressure employed.

(1979) **Compressing Tablets under Vacuum.** *Mech. Eng., 69,* No. 11, 928 (1947). A report on vacuum pressing in a press of F. J. Stokes Machine Company.

(1980) **Pressing under Vacuum.** *Steel, 121,* No. 10, 82 (1947). The F. J. Stokes Mach. Co., Philadelphia, Pa., has perfected a machine and technique of compressing under vacuum metal powders for parts and sintered carbides.

C. Pressing by metal working

(1981) **German Transformer Industry.** A. L. Morris, B.I.O.S. Final Rept. No. 682 (1946). Mannesmann had developed to a laboratory stage a process for compacting R. Z. powder between rollers into sheets which passed a sintering furnace at 1200° C. (2190° F.) in H for 2 minutes.

(1982) **Manufacture of Powder Metal Products by Drawing.** G. Wassermann, F. D. Docum. No. 1314/46,(1946),7 pp.; *Met. Powd. Rept., 1,* No. 5, 70 (1947). Experiments in 1941 on drawing the powder products between a central core and an outer tube. Iron bushings with 10% Pb and 2% graphite were drawn.

After removal of core, sintering is effected at 1200° C. (2190° F.) for 5 hrs. An aluminum bushing containing 8% Al_3Fe was made in similar manner and sintered at 630° C. (1160° F.) for 68 hrs.

(1983) Consolidation of Titanium Powder by Sheath Rolling. J. R. Long, *Metal Progress, 55,* No. 2, 191-2 (1949). A new method of sheath rolling is described in which Ti powder is sealed in metal containers, rolled at elevated temperatures. Powder may be charged loose in container, or pressed; charge is heated to 900° C. (1650° F.).

(1984) Sheath Working of Metal Powders. J. R. Long and E. T. Hayes, *U. S. Bur. Mines Rept. Invest.,* No. 4464, 1949, 13 pp. Investigations described are concerned with portion of research on ductile titanium, undertaken for purpose of improving technique for consolidation of titanium powder into solid non-porous metal; has wide range of application to practically all metal powders or fragments.

D. Presses, dies and attachments.

(1985) A Mold for Casting Cylinders of Fine Powders. J. K. Morse, *J. Opt. Soc. Am., 16,* 360-1 (1928). A mold for use with the Debye camera is described.

(1986) Presses for Powdered Metal Forming. *Metal Ind. (N. Y.), 31,* No. 1, 28 (1933). Zeh and Hahnemann has designed a line of powder presses for the various requirements of metal powders molding.

(1987) Tablet-Making Machine. *Ind. Equipment News, 5,* 50 (1937). Compresses tungsten powder to make contact points.

(1988) Combining Advantages of Hydraulic and Mechanical Operations. J. J. Kux, *Machine Design, 12,* No. 12, 48-50 (1940). Development of combined mechanical hydraulic tablet press which forms parts from powdered metals having high melting point.

(1989) Press for Powder Metals. *Automotive Ind., 84,* 481 (1941). In compressing powder metals it is often necessary to apply slow smooth squeeze to allow more time for metal to flow and to obtain greater hardness; hence, this feature is incorporated in press by F. J. Stokes Mach. Co., Philadelphia, Pa.

(1990) High-Pressure Powder Metallurgy Press. *Metals & Alloys, 13,* No. 5, 594 (1941). New press No. 280 of F. J. Stokes Machine Co., Philadelphia, Pa., is of toggle-action type and delivers up to 50 strokes per min. in fully automatic operation.

(1991) Machinery for Compressing Powdered Metals. L. H. Bailey, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 24, pp. 271-277. Description of a variety of mechanically operated presses.

(1992) Designing Versatile Press for Powder Metal Parts. J. J. Kux, *Machine Design, 14,* No. 10, 59-62 (1942). Tablet press described and illustrated.

(1993) Dies for Fabrication of Porous Bearings. A. J. Langhammer and M. F. Smith, *Metal Progress, 41,* No. 3, 335-337 (1942). Production and sizing equipment described and illustrated.

(1994) Dies for Fabrication of Porous Bearings. A. J. Langhammer and M. F. Smith, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 22, pp. 259-63. Dies and sizing tools for cylindrical bearings are described.

(1995) Die Construction in Powder Metallurgy. A. J. Langhammer and T. L. Robinson, *Modern Ind. Press, 5,* No. 4, 24-28 (1943). In the fabrication of powdered metal porous bearings, two operations require the use of dies, the briquetting or compacting, and the sizing and finishing process. Details of tool and die designs are discussed and illustrated by diagrams and photographs.

(1996) **Dies for Fabrication of Porous Bearings.** A. J. Langhammer and M. F. Smith, *Metal Ind. (London), 62,* No. 6, 89-92 (1943). *Cf. Metal Progress, 41,* No. 3, 335 (1942).

(1997) **Powder Metal Press.** *Metal Progress, 45,* No. 2, 334 (1944). A newly developed high-speed production press by F. J. Stokes Machine Co., Philadelphia, Pa., features pressure applied from top and bottom, which permits molding of new products.

(1998) **Huge Hydraulic Press for Metal Powders.** *Metals Rev., 17,* No. 5, 1 (1944). The Hydraulic Press Manufacturing Co., Mt. Gilead, O., has built huge press especially suitable for pressing carbides.

(1999) **Hydraulic Press for Powdered Metals.** *Metals Rev., 17,* No. 6, 17 (1944). 200-ton duplex hydraulic press made by E. W. Bliss Co., Brooklyn, N.Y., is described.

(2000) **Press for Powdered Metals.** *Metals & Alloys, 19,* No. 1, 229 (1944). New high-speed production test on press made by F. J. Stokes Machine Co., Philadelphia, Pa., is described.

(2001) **Powder Metallurgy Press.** *Metals & Alloys, 19,* No. 2, 476 (1944). A new press of high capacity announced by F. J. Stokes Machine Co., Philadelphia, Pa.

(2002) **Hydraulic Press for Powder Metals.** *Metals & Alloys, 20,* No. 6, 1720 (1944). Specially designed duplex hydraulic press for powder metal industry by E. W. Bliss Co., Brooklyn, N.Y.; 200-ton press for pressing deep sections and flanged objects.

(2003) **Powder Metallurgy Press.** *Iron Age, 153,* No. 12, 76 (1944). Completion of one of largest presses ever built for powdered carbides in hard metals announced by The Hydraulic Press Co., Mt. Gilead, O.

(2004) **Powdered Metal Press.** *Iron Age, 154,* No. 4, 57 (1944). 200-ton hydraulic duplex press announced by E. W. Bliss Co., Brooklyn, N. Y.

(2005) **Presses and Processes for Metal Powder Products.** E. V. Crane and A. G. Bureau, *Iron Age, 153,* No. 26, 36-41 (1944); *154,* No. 1, 62-67 (1944); *Steel, 115,* No. 4, 90-94 (1944). Making of porous products such as bushings, and compression of solid parts; different kinds of presses.

(2006) **Presses and Processes for Metal Powder Products.** E. V. Crane and A. G. Bureau, *Trans. Electrochem. Soc., 85,* 63-86 (1944). Description of press constructions is given.

(2007) **Novel Eccentric Linkage Permits Extended Dwell.** J. J. Kux, *Machine Design, 16,* No. 11, 135-38 (1944). A press having combined mechanical and hydraulic action is described.

(2008) **Pressing and Sintering Carbide Tool Tips.** W. T. Muirhead, *Metals & Alloys, 19,* No. 2, 368-372 (1944). Presses and dies employed in sintered tungsten, titanium and tantalum carbide tool tips production.

(2009) **Materials and Methods Manual. II.** E. E. Schumacher and A. G. Souden, *Metal & Alloys, 20,* No. 5, 1327-1342 (1944). Appendix contains a table on powder metallurgy presses and press manufacturers.

(2010) **New Powder Metal Press.** *Metals Rev., 18,* No. 7, 23 (1945). Designed for high-speed production, made by F. J. Stokes Machine Co., Philadelphia, Pa.

(2011) **Preliminary Survey of German Hydraulic Industry. — Manufacture of Iron Powder Presses.** J. L. Daniels and W. Craig, B.I.O.S.Final Rept. No. 278, 1946. Contains one section on German hydraulic presses used for making flanged bearings.

(2012) **Device for Pressing Metal Powders.** Deutsche Edelstahlwerke A. G. U. S. Dept. Comm. PB. 13728/1941, 6 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 8, 587 (1946). Consists of a rubber chamber with rubber stopper; the edge of rubber chamber being vulcanized to a steel pressure chamber.

(2013) **Sintered Iron and Steel Components.** C. J. Leadbeater, B.I.O.S. Final Rept. No. 595, 1946, 61 pp.; *Met. Powd. Rept. 1,* No. 4, 53 (1946). An interesting

press, used for making feeder components, is described. By means of independently controlled individual punches (up to nine) which operate as a composite unit, the different sections of the component are subjected to uniform compression. The die assembly is pulled downward, giving double-action type of pressing, and spring-loaded punches are selectively released at the end of the operation to facilitate removal of the pressed part from the minimum number of punches. In a press of this type, the powder adjacent to the die walls is compacted to about the same degree as the powder adjacent to the punches.

(2014) New Equipment – Briquetting Press. *Iron Age, 160,* No. 4, 71 (1947). A brief description is given of a new Bliss briquetting press for metal powders.

(2015) Automatic Press Moulds Sparking Plug Insulators. *Machinist (London), 90,* 1943-1947 (1947). A description is given of a new hydropneumatic press for the manufacture of metal-ceramic bodies (*e.g.*, for sparking plugs), operating on the principle of a rotary press with 24 work stations.

(2016) Powder Metal Press. *Materials & Methods, 25,* No. 5, 139 (1947). Cam-type press of 40 ton capacity made by I. J. Stokes Machine Co. delivers up to 30 strokes/min.

(2017) New Developments in the Production of Metal Powder Parts. E. E. Ensign, *Proc. Third Ann. Meeting Metal Powder Assoc.,* New York, May 27, 1947, pp. 14-20; *Automotive Inds., 97,* No. 4, 30-33 (1947). Tools for producing metal powder parts developed by Ford Motor Company are described.

(2018) Kilian Press. Studiengesellschaft Hartmetall. F. D. Rept. No. 3793/47 (1947). A brief description of the Kilian tableting press with instructions for use with hard metal powder, dated 1938.

(2019) Metal Powder Press. *Iron Age, 161,* No. 5, 79 (1948). In a 30-60 ton press made by Continental Machines, Inc., pressures are applied from top, bottom and sides simultaneously through hydraulic cylinders.

(2020) Metal Powder Press. *Iron Age, 162,* No. 10, 95 (1948). F. J. Stokes Machine Co. now make a 12 ton press giving simultaneously top and bottom pressure. A movable core rod is built in that can drop before the die is filled, to assure uniform distribution and a full die cavity.

(2021) DoAll Powder-Metal Press. *Machinery (N. Y.), 54,* No. 6, 195 (1948). The construction and use of the press is described.

(2022) Die Materials. *Steel, 122,* No. 2, 98 (1948). Installation of carbide cut-out and cupping dies in a nine-stage progressive die set by Thompson Products Co. and Carboloy Co.

(2023) Metal Density Assured by Special Press. *Steel, 122,* No. 6, 96 (1948). Metal density assured by a 30-60 ton hydraulic powder press equipment on which pressure is applied simultaneously from top to bottom as well as from sides through hydraulic cylinders.

(2024) Press Molding Machine. Arbeitsgemeinschaft Pulvermetallurgie. F. D. Rept. No. 159/48 (1948). A set of drawings of a press for small arm components with a die and independently sprung punch segments, to produce sections of different thickness with uniform density, were developed in 1942.

(2025) Tooling for Powder Metal Parts. W. E. Dalby, *Proc. Fourth Ann. Spring Meeting Met. Powd. Assoc.,* Chicago, Apr. 15-16, 1948, pp. 36-49. Construction of some types of dies and punches for pressing are given.

3. SINTERING

(2026) High Temperature Equipment for Sintering Combinations of Ceramic Oxides and Metal Powder. A. R. Blackburn, *Ohio State Univ., Eng. Exptl. Sta. News, 19,* No. 5, 24-28 (1947). These combinations are playing an important part in the development of materials suitable for use in jet-propulsion mechanisms. Furnaces for sintering these mixtures are described.

(2027) Sintering of Metal Powders. R. Talmadge, *Ind. Gas, 27,* No. 1, 11, 24 (1948). A discussion of the contribution of metal powder methods and sintering; best sintering practice for copper, brass and steel sintering.

(2028) Technical Equipment for Powder Metallurgy. F. Krall, *Einführung in die Pulvermetallurgie,* Technische Hochschule Graz, 1949, pp. 55-83. Equipment for the production of high melting metals and sintering furnaces are described.

A. By indirect heating (bath, pack, controlled atmosphere, vacuum)

(2029) Inflammability of Mixed Gases. G. W. Jones, *U. S. Dept. Commerce, Bureau of Mines, Tech. Paper No. 450,* 1929, 38 pp. An atmosphere recirculation system suitable for reduction and sintering is described on pp. 37-38.

(2030) Decarburization of High Carbon Iron by Hydrogen. W. Baukloh, W. v. Kronenfels, and H. Guthmann, *Stahl u. Eisen, 54,* No. 52, 1334-36 (1934). The reaction which takes place when sintering metals containing carbon in an atmosphere containing hydrogen is investigated.

(2031) Gases for Controlled Atmospheres. E. E. Slowter and B. W. Gonser, *Metals & Alloys, 9,* No. 6, 159-168; No. 7, 195-205 (1938). As sources of controlled atmospheres, hydrogen-nitrogen, hydrogen-carbon monoxide-nitrogen, hydrogen-methane, carbon monoxide-nitrogen, and partly burned fuel gases are given. The carbon dioxide removal during heat treatment is essential to prevent decarburization. Experimental work with atmospheres containing small amounts of carbon dioxide and methane are described. Requirements for purification of the gases are cited.

(2032) Annealing with Protective Atmospheres. W. Baukloh, *Korrosion u. Metallschutz, 15,* 357-67 (1939). Different gases as protective atmospheres in the annealing of metals are discussed, and gas-metal reactions are treated.

(2033) Electrical Industrial Furnaces with Molybdenum Heating. R. Kieffer and F. Krall, *V. D. I. Fachberichte, 11,* 107-112 (1939). Temperature ranges of the furnaces; field of applications. Ceramic materials and forms of constructions.

(2034) Protective Gases for Electrical Furnaces. F. Pawlek, *Elektrotech. Z., 60,* 1445-48, 1475-78 (1939). The manner of the reaction of gases with metals is investigated. Of special interest in the sintering of metals.

(2035) Protective Gases for Electric Furnaces. G. Simon, *Tech. Zentralbl. prakt. Metallbearbeitung, 49,* 379-82 (1939). Cracked and partially combusted hydrocarbon gases (*e.g.,* propane or city gas) are suitable as sintering atmospheres.

(2036) Chemical Equilibrium and the Control of Furnace Atmosphere. J. B. Austin and M. J. Day, *Ind. Eng. Chem., Ind. Ed., 33,* 23-31 (1941). The control of conditioned atmospheres in metallurgical furnaces is described.

(2037) Production of Protective Gases of Ammonia. K. A. Lohausen, *Z. Ver. deut. Ing., 85,* 917-18 (1941). Dissociated ammonia as furnace atmosphere is suitable for sintering.

(2038) Bright-Annealing. G. Simon, *Elektrowärme, 11,* 193-198 (1941). Cracked and partially combusted hydrocarbon gases, as suitable for sintering, are described.

(2039) Safety Measures in Bright Annealing and Related Equipment. H. Zeller, *Reichsarbeitsblatt No. 14,* Arbeitsschutz No. 5, 1941. Safety and economy in atmosphere recirculation systems, such as can be used in reduction and sintering operations, is discussed.

(2040) Vacuum Aids Formation of Powder Metallurgical Compacts. C. Hardy, *Steel, 110,* No. 3, 64, 86 (1942). Vacuum atmosphere during sintering.

(2041) Development of Sintered Alnico. G. H. Howe, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 48, pp. 530-36. Hydrogen purification batch type furnace, and boat construction described.

(2042) Electric Furnace in Powder Metallurgy. R. Kieffer and F. Krall, *Elektrowärme, 12,* 33-37 (1942). Reduction furnaces and sintering furnaces are described; special reference to molybdenum as heating element is made.

(2043) Sintering Furnaces and Atmospheres. R. P. Koehring, *Metal Ind. (London), 61,* No. 12, 183-85 (1942). A furnace is described which is so designed that the physical properties and dimensional changes of sintered parts can be controlled.

(2044) Sintering Furnaces and Atmospheres. R. P. Koehring, *Metal Progress, 41,* No. 5, 657-62, 722 (1942). The problems involved in commercial full time production of porous-metal bearings from Cu and Sn powders, and other parts from Fe powder are discussed with reference to sintering and the effect of size and other variables in materials. A furnace has been designed to control physical properties and dimensional changes.

(2045) Sintering Methods and Atmospheres for Production Purposes. R. P. Koehring, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 25, pp. 278-291. Character of powder, composition, briquetting pressure, manner of sintering, atmospheres discussed.

(2046) Production of Protective Gases of Ammonia. K. A. Lohausen, *Tech. Zentralbl. prakt. Metallbearbeitung, 52,* 8-9, 31-32 (1942). Dissociated ammonia as furnace atmosphere is suitable for sintering.

(2047) Furnaces and Atmospheres for Sintering Powder Metallurgy Products. H. M. Webber, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 26, pp. 292-303. Description of different furnaces and gases used as sintering atmospheres.

(2048) Theoretical Fundamentals of the Annealing of Metals in Protective Atmospheres. W. Baukloh, *Gas- u. Elektrowärme, 43,* IV, No. 1, 5-9 (1943). An analysis of different gases, including cracked hydrocarbons, and their reactivity with different metals.

(2049) Contribution on the Thermal Decomposition of Carbon Monoxide on Iron, its Alloys and Mixtures with Carbon. F. Körber, H. Wiemer, and W. Fischer, *Arch. Eisenhüttenwesen, 17,* 43-52 (1943/44). The effects of sintering atmosphere and composition of getters and packs on the decarburization of sintered steels were investigated. Quartz and alundum were studied as packs. The reaction of the combined carbon with the oxygen of the entrapped air is held as the main cause for the decomposition.

(2050) Furnaces for Sintering Powdered Metal. *Metals & Alloys, 19,* No. 5, 1284 (1944). A line of high-temperature electric furnaces is announced by Harper Electric Furnace Corp. for manufacturing of metal powder products.

(2051) Industrial Protective Atmospheres. F. Pawlek, *Werkstattstechnik, Betrieb, 38,* No. 23, 65-69 (1944). A review is given of the various industrially important gases for heat treating, annealing, and sintering.

(2052) Controlled Atmospheres for Bright Hardening. C. E. Peck, *Metals & Alloys, 19,* No. 3, 593-99 (1944). A description is given of the Endo gas cracker and controlled atmosphere generator.

(2053) Special Purpose Atmospheres. K. Rose, *Metals & Alloys, 20,* No. 6, 1639 (1944). Part of Engineering File Facts. Atmospheres for powder metallurgy operations: hydrogen, dissociated ammonia and city or natural gas.

(2054) The Principles and Practice of Lithium Heat-Treating Atmospheres. C. E. Thomas, *Ind. Heating, 11,* No. 9, 1405-16 (1944). Li vapor reacts with water vapor, oxygen, and any other oxidizing components in the furnace atmosphere and thus renders the latter non-oxidizing to the steel. The Li is regenerated in the atmosphere by reaction of LiO_2 with CO.

(2055) Ammonia for Processing Metals. E. R. Woodward and R. J. Quinn, *Metals and Alloys, 22,* No. 2, 418-424 (1945). Dissociated ammonia as sintering atmosphere.

(2056) Sintering Atmospheres. *Iron Age, 157,* No. 25, 80 (1946). Discussion of a paper presented at the Spring meeting of the Metal Powder Association by H. M. Webber and A. G. Hotchkiss.

(2057) Some Users' Experience with Lithium Atmosphere for Heat Treating. R. S. Burpo, *Materials and Methods, 24,* No. 3, 622-25 (1946). The particular furnace types and the controlled atmosphere are described. Of interest to powder metallurgists engaged in sintering steel parts.

(2058) Growing Use of Prepared Atmospheres. E. G. DeCoriolis, *Ind. Gas, 25,* No. 1, 10, 24, 26 (1946). Use of prepared atmospheres in the prevention of changes in the surface of the metal during treatment and causing desired changes is described. Considerations apply to sintering atmospheres.

(2059) I. Jenkins, *Controlled Atmospheres for the Heat-Treatment of Metals.* Chapman & Hall, London, 1946, 532 pp. Book is arranged in three sections covering the generation, purification and application of controlled atmospheres. Of considerable significance for consideration of sintering furnace atmospheres.

(2060) A High Temperature Vacuum Sintering Furnace. R. H. Myers, *Proc. Australasian Inst. Mining Met., 144,* 327-339 (1946). Description of a furnace for vacuum sintering of Ta powder compacts with specimen 14 in. long.

(2061) Furnace Atmospheres for Sintering. H. M. Webber and A. G. Hotchkiss, *Proc. Second Ann. Spring Meeting of Met. Powd. Assoc.,* New York, June 13, 1946, pp. 13-39. Hydrogen, dissociated ammonia, partially burned fuel gas discussed; also gas generation, scrubbing and drying equipment.

(2062) Classification of Prepared Atmospheres. C. C. Eeles and M. E. Shriner, *Metal Progress, 52,* No. 2, 256B (1947). Tabulation of gases according to exothermic, prepared nitrogen, endothermic, charcoal and ammonia base, taken from the American Gas Association, Industrial and Commercial Gas Section, Information Letter No. 9.

(2063) Sintering of Metal Powder in Hydrogen. Fried. Krupp A. G., Essen, F. D. Rept. No. 1314/47 (1947). Report, covering experiments in 1937-43, describes that a pressing of 7 g. metal powder (not specified) was sintered in hydrogen with repeated partial evacuation. 60 cc. gas, consisting of CO_2, H_2 and CH_4, was given off below 1000° C. (1830° F.).

(2064) Hard Metal. Studiengesellschaft Hartmetall. F. D. Rept. No. 3732/47 (1947). Effect of hydrogen purity in hard metal sintering was studied in 1934.

(2065) Furnaces. Studiengesellschaft Hartmetall. F. D. Rept. No. 3737/47 (1947). Analysis of exit gases from carbon tube furnace, as used in the sintering of cemented carbides, were reported in 1935.

(2066) Tungsten Wired Furnace. Studiengesellschaft Hartmetall. F. D. Rept. No. 3741/47 (1947). Alumina bodies for carrying the wiring in tungsten-wired furnace suitable for the sintering of hard metal compositions are described in this report of 1936.

(2067) Molybdenum-Wired Carbide Sintering Furnaces. Studiengesellschaft Hartmetall. F. D. Rept. No. 3755/47 (1947). According to this report of 1936, the use of silica refractories in molybdenum-wired furnaces may lead to decarburization of the carbide and formation of silicon deposits during sintering.

(2068) Vacuum-Sintering of Cobalt, and Cobalt-Cemented Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3792/47 (1947). According to this report of 1938, vacuum-sintered cobalt is denser than cobalt sintered in a carbon-tube furnace in either hydrogen or nitrogen, the latter being also slightly carburized. With 95/5 WC-Co vacuum sintering gives constantly increasing densities up to 1750° C. (3180° F.), with peaks for the other methods. Blistering occurred only in the latter cases after the peak density had been passed. The changes are very clearly shown by metallographic tests.

(2069) Temperature Control for Furnaces. Studiengesellschaft Hartmetall. F. D. Rept. No. 3925/47 (1947). Experiments to develop a semi-automatic temperature control for carbon tube furnaces were conducted in 1942.

(2070) Alumina Packing and Microstructure. Studiengesellschaft Hartmetall. F. D. Rept. No. 3946/47 (1947). The effect of the quality of the alumina packing upon the microstructure of F-1 type German cemented carbide tips is discussed in this report of 1943.

(2071) Furnace Atmospheres for Sintering. H. M. Webber and A. G. Hotchkiss, *Ind. Heating, 14,* 742, 1084, 1254 (1947). Discussion covers hydrogen, dissociated ammonia, and partly burned fuel gases. Atmospheres used in sintering metal powder compacts must be such as to prevent any undesirable chemical reactions from taking place.

(2072) Non-Ferrous Metals Comm. Final Report. W. W. Young, *Proc. Am. Gas. Assoc., 29,* 468-69 (1947). Brief mention is made of the progress of various concerns in application of gas heating to sintering.

(2073) Sintering Furnaces and Atmospheres. H. C. Bostwick, *Ind. Heating, 15,* 1664, 1668, 1670, 1831 (1948). Furnaces and the equipment for the production of metal powder compacts are described.

(2074) Sintering with Increased Vacuum. S. Jansson and C. Danielsson, *Jernkontorets Ann., 132,* 15-20 (1948). Using the Greenawalt sintering machine; vacuum 400, 700, 900 in. water; the rate of sintering increases with the square root of vacuum; the quality of sintered iron is not effected by higher vacuum.

(2075) Heat Processing Easily Oxidized Metals. F. C. Kelley, *Iron Age, 161,* No. 21, 84-9 (1948). Discussion of technique for purifying and applying hydrogen atmosphere for furnace brazing and construction of such furnaces. Conditions for highly purified atmospheres in certain sintering operations are described.

(2076) Electrical High-Temperature Furnaces with Molybdenum Resistors. R. Kieffer and B. Natter, *Radex Rundschau,* No. 3/4, 49-56 (1948). Characteristics of Mo; Mo furnaces; constructions; temperature measurement and regulation; protective atmosphere; applications. Description includes *(1)* a tiltable continuous furnace, *(2)* a muffle furnace, and *(3)* an American continuous furnace.

(2077) Protective Atmospheres. N. K. Koebel, *Metal Ind. (N. Y.), 72,* No. 21, 426-27 (1948). Comparison of the methods of atmosphere generation available for the sintering process.

(2078) Sintering Atmospheres Used in Powder Metallurgy. N. K. Koebel, *Proc. Fourth Ann. Spring Meeting Met. Powd. Assoc.,* Chicago, April 15-16, 1948, pp. 6-18. The relative costs of sintering atmospheres are given and schematic flow diagrams of hydrogen atmosphere generators are shown. Belt furnaces, roller hearth furnaces, hand pusher furnaces are discussed.

(2079) Controlled Atmosphere Furnaces for Nonferrous Metals. W. Lehrer, *Metal Progress, 53,* No. 3, 393-402 (1948). Author has summarized information on modern practice of heat treating furnaces in bright annealing of the heavy nonferrous metals and alloys. May be applied to sintering of powder metallurgy products.

(2080) Molybdenum-Vacuum Furnace. *Iron Age, 163,* No. 25, 84 (1949). A trade note from Pereny Equipment Co. states that the operating temperature is 1800° C. (3270° F.) with power consumption of 6 kw. Chromium compacts can be sintered without oxidation.

(2081) W. Baukloh, *Schutzgasglühung.* Akademie-Verlag, Berlin, 1949, 36 pp. Fundamentals and operations concerning protective atmosphere annealings are described, and the conditions for the carburizing of iron during annealing are included. Of interest for the sintering of steel powder parts.

(2082) High Temperature Furnaces. Modern Equipment for Processing Sintered Carbides. H. D. Hendrick, *Automobile Eng., 39,* 284-86 (1949). A general article featuring a presintering furnace, up to 1000° C. (1830° F.), and a sintering furnace, up to 1700° C. (3090° F.) made by James Royce Electric Furnaces Ltd. for carbides.

B. By direct heating (electrical, resistance, high frequency, exothermic processes)

(2083) Ductile Tungsten. W. D. Coolidge, *Trans. Am. Inst. Elect. Eng., 29,* 961-65 (1910). The sintering of tungsten rods, by heating them through their own resistance when passing a high amperage current through them, is described.

(2084) On the Phenomenon of Hollowing of Tungsten Bars by Central Fusion. P. Woog, *Bull. Soc. Chim. France, 39,* 1708-11 (1926). When, during the sintering of pressed W bars by a heavy current, too large a current is employed, the center of the bar may fuse, leaving a hollow space in middle; then the surrounding metal shows recrystallization.

(2085) Apparatus for the Preparation of Rods of High Melting Alloys. F. Beck, *Z. tech. Phys., 14,* 554-6 (1933). Description of apparatus. Sintering apparatus with resistance heating for high temperatures to form alloys by diffusion.

(2086) Mercury Vapor as an Indifferent Atmosphere Especially at Atmospheric Pressure. F. Skaupy, *Z. Elektrochem., 49,* 186-188 (1943). Mercury vapor counteracts to a considerable extent the evaporation of certain metals during sintering, especially by the direct resistance method. Metals that benefit by such treatment are not only titanium, tantalum, chromium and uranium, but also tungsten, molybdenum and platinum as well as carbides.

(2087) Induction Furnace for High-Temperature Ceramic Research. P. D. Johnson, *J. Am. Ceram. Soc., 32,* 316-19 (1949). Describes a high-frequency induction unit with Mo susceptor and radiation shields for 2300° C. (4170° F.).

C. By heating without previous compaction (thermal sintering)

(2088) Sintering Process and Some Recent Developments. J. E. Greenawalt, *Trans. Am. Inst. Mining Met. Engrs., 131,* 44-66 (1938). Sintering of iron ores; porosity, size of charge, cooling, etc.

(2089) Sintering Powders. L. Delisle, *Steel, 115,* No. 12, 131-32, 154 (1944). The bonding of metal by heat alone without the application of pressure is investigated. *Cf.* item 2090.

(2090) Sintering Powders. — Bonding Metal Particles by Heat Alone Without Pressure. L. Delisle, *Trans. Electrochem. Soc., 85,* 135-153 (1944). Results of microscopic examination and physical tests of specimens made of metal powder by sintering in hydrogen for 3 hours at various temperatures. Powders of different particle size and shape were filled into the boats without application of any pressure. Fe, Cu and Ag powders investigated.

(2091) Magnetic and Electrical Studies of Sintered Carbonyl Nickel. W. Gerlach, J. von Rennenkampff and A. Brill, *Z. Metallkunde, 39,* 130-132 (1948). Specimens are made by sintering without pressure a Ni carbonyl powder containing 0.05% C, 0.04% Fe. The sintering in air produced an oxidation of the particles at a temperature below 1000° C. (1830° F.), when density was highest; equivalent mechanical, magnetic and electrical properties were obtained when tested to 350° C. (660° F.) regardless of the atmosphere of sintering.

4. COMBINED PRESSING AND SINTERING

(Hot pressing and pressure sintering)

(2092) On Synthetic Metal Bodies – V. F. Sauerwald and J. Hunczek, *Z. Metallkunde, 21,* No. 1, 22-23 (1929). New experiments in the preparation of synthetic forms from metal powders. Hot-pressing of copper and iron compacts; tensile strength test results.

(2093) Hard Metal Carbides and Cemented Tungsten Carbides. S. L. Hoyt, *Trans. Am. Inst. Mining Met. Engrs., 89,* 9-58 (1930). Description of hot pressing of cemented carbides is given.

(2094) On Synthetic Metal Bodies – VI. F. Sauerwald and St. Kubik, *Z. Elektrochem., 38,* 33-41 (1932). Hot pressing experiments with powdered white cast irons, apparatus are described.

(2095) Hot-Press Experiments with Highly Dispersed Metallic Powders. W. Trzebiatowski, *Z. physik. Chem., A169,* 91-102 (1934). Hot-pressing of copper and gold powders at pressures up to 100 tsi and 600° C. (1110° F.) under hydrogen atmosphere.

(2096) On the Problem of Producing Hard Alloy by Hot-Pressing. B. A. Borok, and N. M. Zarubin, *Niimash,* No. 4, 28-35; *Met. Abstracts, 2,* 725 (1935). Hot-pressing is unprofitable for hard alloys with a low melting bond, but it can be rationally applied for the production of hard alloys of cast-type. The hardness and the tenacity of hot-pressed alloys are higher than those of cast alloys.

(2097) Powder Metallurgy of Iron with Particular Reference to Pacteron. W. D. Jones, *Foundry Trade J., 59,* 401-02 (1938); *Iron & Coal Trades Rev., 137,* 1013-14 (1938). A cast iron powder base composition is produced by hot pressing.

(2098) C. G. Goetzel, *The Influence of Processing Methods on the Structure and Properties of Compressed and Heat-Treated Copper Powders,* Dissertation, Columbia University, 1939, New York. Hot pressing of copper powders and apparatus described. Results of hot pressed compacts compared with those of sintered compacts.

(2099) Some Properties of Hot-Pressed and Sintered Copper Powder Compacts. C. G. Goetzel, *Trans. Am. Soc. Metals, 28,* No. 4, 909-932 (1940). Hot pressing technique is described and properties of compacts are discussed.

(2100) Powder Metallurgy. W. D. Jones, *Metal Ind. (London), 56,* No. 3, 69-71 (1940). Principles upon which progress is being made with reference to compaction of metal powders by hot-pressing.

(2101) Hot-Pressing of Metal Powders. W. D. Jones, *Metal Ind. (London), 56,* No. 10, 225-228 (1940). Manufacture of copper alloys by hot-pressing metal powders. No precautions are taken to prevent oxidation. Non-porous alloys obtained.

(2102) Briquetting of Bronze Chips in an Eccentric Press. D. S. Doino, *Liteinoe Delo, 12,* No. 7-8, 24-7 (1941). Advantageously briquetted at high temperatures. Bronze containing 9-10% Al, 2.5-3.5% Fe, 0.60% Pb, rest Cu can be briquetted also in the cold state with a frictional or eccentric press.

(2103) Hot-Pressing of Iron Powders. P. Schwarzkopf and C. G. Goetzel, *Iron Age, 148,* No. 10, 37-44 (1941). Apparatus and technique described; pressure-temperature relation is established.

(2104) Hot-Pressing of Swarf. *Machinery (London), 61,* 6 (1942). Consolidation of metal powder compacts by hot-pressing and hot-repressing is discussed.

(2105) Hot-Pressing of Iron Powders. C. G. Goetzel, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 36, pp. 395-407. Apparatus and technique, pressing temperature, hot pressing cycle, and subsequent annealing are investigated.

(2106) Some Properties of Sintered and Hot-Pressed Copper-Zinc Powder Compacts. C. G. Goetzel, *Trans. Am. Soc. Metals, 30,* No. 1, 86-123 (1942); *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 34, pp. 452-378. Technique and properties are presented.

(2107) Hot-Pressing of Metal Powders. W. N. Pratt, A. S. T. M. Symposium on Powder Metallurgy, Philadelphia, Pa., 1943, pp. 49-55. General advantages of hot-pressing. Papers by Comstock, Goetzel and Jones discussed; patent situation; discussion by C. G. Goetzel, C. Hardy, J. Q. Adams, A. J. Langhammer, E. W. Engle.

(2108) Hot-Pressing and Sintering of Large Carbide Powder Parts. *Iron Age, 153,* No. 23, 71 (1944). Ability to produce cemented carbide parts too large to be sintered in available furnaces – as well as special thin-walled parts – has been made possible by the development of hot-pressing.

(2109) Large Carbide Die Nibs Formed by Hot-Pressing. *Metal Progress, 45,* No. 4, 681-82 (1944); also *Steel, 114,* No. 22, 99 (1944). Cemented carbide die nibs too large to be sintered in available furnaces have been made by Carboloy Inc. by the hot-press method.

(2110) Some Properties of Sintered and Hot-Pressed Copper-Tin Powder Compacts. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 161,* 580-595 (1945). Technique and properties are discussed.

(2111) Metal Powder Hot-Press. *Iron Age, 158,* No. 16, 74 (1946). Designed for laboratory use in developing and producing special powdered metal alloys, a machine for hot-pressing non-ferrous metals has been developed by National Diamond Hone & Wheel Co., New York.

(2112) Powdered Metals Hot-Pressed. *Product Eng., 17,* No. 11, 93 (1946). New hot-press machine built by Diamond Hone Wheel Co., New York, and designed for laboratory use.

(2113) New Cemented Carbide Compositions. M. I. Genzelovich, *Automobilnaja Promyslenost,* No. 9/10, 20-21 (1946). The production of WC-Co hard metals with 3-8% Co by hot-pressing for compositions with increased hardness is described.

(2114) Hot-Pressing of Iron Powder. O. Henry and J. Cordiano, *Trans. Am. Inst. Mining Met. Engrs., 166,* 520-532 (1946). Experimental work on electrolytic iron powder, tensile properties, time factor. Discussion.

(2115) Titanium Hydride Increases Compact Density. H. L. Strauss, Jr., *Steel, 118,* No. 18, 138, 160 (1946). Details of technique for use of TiH in hot-press or semi-hot-press method. In addition to increasing density, method improves other physical properties of metal powders. 5% TiH is sufficient to remove or prevent formation of oxide films during hot-pressing in air.

(2116) Improvements in Powder Metallurgy. *Chem. Age (London), 57,* No. 1465, 192 (1947). A discussion of British Patent Application No. 13447/1947,(issued as British Patent No. 623,854,1949) by Charles Hardy, Inc. for heating contact points between particles by an electric current in a hot-press.

(2117) Moment of Active Deformation. H. L. Strauss, Jr., *Metal Progress, 51,* No. 2, 254-5 (1947). Advantages of the hot-pressing method used for setting diamonds in tools or holders; comparison with conventional pressing and sintering technique. Method permits use of very light pressures, and involves only seconds.

(2118) Polyvinyl Acetate in Powder Metallurgy. H. L. Strauss, Jr., *Modern Plastics, 24,* No. 10, 196, 198 (1947). The process uses a resistance-heated carbon die which applies variable heat and pressure. With this process Cu, Ni, Sn and Zn can be alloyed and hot-pressed; 5% polyvinyl acetate is added to improve the flowability of the powder while under heat and pressure.

(2119) Manufacture of Bearings and Other Machine Parts by Hot-Forging. G. Wassermann, F. D. Doc. No. 1306/46, 1947, 4 pp.; *Met. Powd. Rept., 1,* No. 5, 74-75 (1947). Two hot-pressing methods were put to large-scale tests for manufacture of pistons and bushings at Metallgesellschaft A. G. First method involves heating powder in a slightly tapered graphite crucible at 800° C. (1470° F.); the resulting cake is hot-forged in an eccentric or spindle press. The second method involved forging a heated but not caked powder mass.

(2120) Hot-Pressing Metal Powders. *Iron Age, 161,* No. 4, 60 (1948). Results of investigation into working of metal powders are revealed by G. Wassermann in *Metallforschung, 2,* 129, 1947. It is possible to sinter parts firmly by applying a wash of iron powder and water. Hot-pressing can be simplified by eliminating initial cold pressing.

(2121) Ford Uses a Hot Press Diamond Setting Machine. *Iron Age, 164,* No. 2, 116 (1949). The construction and production of the Strauss machine is described.

(2122) Process for Hot Pressing Beryllium Powder. A. U. Seybolt, R. M. Linsmayer, and J. P. Franssen, *U. S. Atomic Energy Comm. Publ. 2679,* 1949, 23 pp. Hot pressed Be powder compacts have been made of almost theoretical density of 1.86 g./cc., the optimum conditions of pressing being 30-45 min. at 750-1000 psi at 1100° C.

(2123) Principles and Present Status of Hot-Pressing. C. G. Goetzel, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chap. 15, pp. 256-277. A review of this subject is given, in which due acknowledgment is made of the accomplishments of the technique with regard to physical properties obtainable in hot-pressed compacts, but emphasis is laid on the prevailing technical and commercial limitations of the method. Hot-pressing of cemented carbides constitutes the only application of industrial significance at present.

5. EXTRUSION OF COMPACTS
(Refractory metals, lower melting metals)

(2124) Extrusion of Metal Powders. W. D. Jones, *Metal Ind. (London), 57,* No. 2, 27-30 (1940). Several patents on extrusion apparatus described.

(2125) Extrusion of Metal Powders. R. H. Leach, *Steel, 107,* No. 16, 164-165 (1940). Manufacture of bearings with a strongly bonded layer of metal powder to a steel strip. The extrusion of metal powder products is improved by Carboloy Co. to produce rods, spirals, tubes.

(2126) Coalesced Copper – Its History, Production and Characteristics. H. H. Stout, *Trans. Am. Inst. Mining Met. Engrs., 143,* 326-334 (1941). Electrolytic copper powder is briquetted and extruded. Discussion.

(2127) Coalescence Process for Producing Semifabricated Oxygen-Free Copper. J. Tyssowski, *Trans. Am. Inst. Mining Met. Engrs., 143,* 335-339 (1941). Process of the Copper Deoxidation Corp. Brittle electrolytic Cu is briquetted under pressure, then extruded into profiles. Discussion.

(2128) Experimental Extrusion Apparatus. W. Bullian, *Metallwirtschaft, 23,* 249-50 (1944). An extrusion press suitable for handling small sample work of powdered metal bodies as billets is described.

(2129) Extrusion in Powder Metals. R. Kieffer and W. Hotop, *Metallwirtschaft, 23,* No. 40/43, 379-86 (1944). Compacts were prepared from iron, nickel, Cu, Ag, W-Cu, W-Ag by cold pressing, sintering at high temperatures, and then extruded into wires, tubes and sections. Microstructure, density, hardening, mechanical properties of products were studied.

(2130) C. E. Pearson, *The Extrusion of Metals.* Chapman & Hall, London, 1944, 201 pp. On pp. 198-201, the extrusion of particles of cathode copper, hard carbides, and copper welding rods is described.

(2131) Extruding Powdered Metals to Form Synthetic Welding Wire. F. G. Daveler, *Materials & Methods, 23,* No. 5, 1317-1320 (1946). Extrusion of metal powder and flux coating layer around welding wire.

(2132) Extruding Powdered Metals to Form Synthetic Welding Wires. F. G. Daveler, *Machinery Lloyd, 18,* No. 26, 86 (1947); *Met. Abstracts, 15,* 106 (1947). Extruding powdered metals and compacting them around drawn wire.

(2133) Extrusion of Sintered Aluminum Compacts. A. v. Zeerleder, *J. Inst. Metals, 75,* 1143-46 (1948/49). In the discussion of the paper "Pure Platinum of High Crystallization Temperature Produced by Powder Metallurgy" by A. B. Middleton, L. B. Pfeil, and E. C. Rhodes, it is mentioned that the characteristics of specimens prepared by extruding sintered powder compacts are compared with those of cast and extruded pure aluminum.

(2134) Extruded Pure Molybdenum Seamless Tube. *Chem. Eng. News, 27,* 644 (1949). Tubes of pure molybdenum are reported on; they are produced by extrusion, weigh about 20 lbs., have a length of 43 inches, an outside diameter of 2 inches, and a wall thickness of 1/4 inches.

6. METAL WORKING

A. Repressing, coining, and sizing

(2135) A. Schubert and F. Georgi, *Die Technik der Stanzerei, das Pressen, Ziehen und Praegen der Metalle,* 4th Ed. Max Janecke, Leipzig, 1924. The technique of stamping, pressing, drawing and coining of metals is treated in form of a text. Special references are made to machinery. Section on coining of interest for metal powder parts production.

(2136) Plastic Deformation in Powder Metallurgy. C. G. Goetzel, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 7, pp. 87-108. Repressing and working subsequent to sintering is described.

(2137) E. V. Crane, *Plastic Working of Metals & Non-Metallic Materials in Presses.* 3rd Ed., Wiley, New York, 1944, 540 pp.; Chapman & Hall, London, 1944. Book on sheet metal working and forging has been expanded to include powdered metals and synthetic plastic powders. Methods used in working these materials are studied and described in detail and effort is made to classify metal working operations into groups and to establish working theory for predicting results with various materials.

(2138) Bonded Sapphire-Metal Material for Sizing. T. C. DuMond, *Materials and Methods, 26,* No. 4, 84-86 (1947). Sapphire soldered to metal parts by a special process is used to size surfaces of powder metallurgy bearings.

(2139) Ford Utilizes Extrusion Method for Producing Metal Powder Gears. E. E. Ensign, *Automotive Ind., 97,* No. 4, 30-1, 72 (1947). A new method involves restriking of metal powder parts and is considered as an extrusion process, using punches, die body and extrusion plate for external sizing of part. The process was developed for an oil pump gear.

(2140) New Developments in the Production of Metal Powder Parts. E. E. Ensign, *Proc. Third Ann. Spring Meeting, Metal Powder Assoc.,* New York, May 27, 1947, pp. 14-20. Ford Motor Co. has developed a new concept of coining (re-striking) metal powder parts and new tools whereby better parts may be produced. Oil pump gears cited as an example.

B. Cold and hot working (rolling, hammering, forging, swaging, drawing)

(2141) Method of Rendering Platina Malleable. W. H. Wollaston, *Phil. Trans. Roy. Soc., 119,* 1-8 (1829). Historical interest. Pt ground to powder, compressed in a crude press, heated in a charcoal fire and finally in a wind furnace, then hot-forged.

(2142) Manufacture of Filaments. G. Ricard, *Electricien, 57,* 11-21 (1926). Methods of making filaments by drawing through diamond dies with graphite as a lubricant.

(2143) The Improvement of Cold-Worked Mix-Crystal Wire. K. Becker and C. Agte, *Z. tech. Phys., 11,* 107-11 (1930). Deals with sintered tungsten, molybdenum, tantalum wires and their ductility.

(2144) Drawing of Wires of Ultrafine Diameter. K. Moers and K. Sichling, *Werkstattstechnik u. Werksleiter, 30,* 21-23 (1936). Description is given of a process by which tungsten rod may be drawn to filament-size wire.

(2145) P. E. Wretblad, *Svenska Metallografförbundets Härdhetshandbok.* Upsala, Sweden, 1937. On p. 166, the author discusses the deformation of a metal as a function of temperature, as for instance applied to tungsten. He distinguishes four separate zones: *(1)* characterized by low temperature brittleness; *(2)* ability to be cold worked; *(3)* ability to be hot worked; and *(4)* above the melting point.

(2146) Rolled Molybdenum Sheet. C. E. Ransley and H. P. Rooksby, *J. Inst. Metals, 62,* 205 (1938). Special rolling tests in crystallographic planes are described.

(2147) Pure Iron Powder. A. H. Allen, *Steel, 104,* No. 15, 43-54 (1939). The hot repressing at 500° C. (930° F.) of automobile parts from sponge iron immediately after removal from the sintering furnace is described.

(2148) The Production of Molybdenum and Tungsten Wire. W. D. Relyea, *Wire & Wire Products, 14,* 258-60, 283 (1939). Complete production from the refractory metal powders and sintered ingots to the finished drawn wires and filaments is described. Special emphasis on metal working techniques.

(2149) Diamond Dies. *Philips Tech. Rev., 5,* No. 1, 14-15 (1940). The drawing of tungsten wire through diamond dies is described.

(2150) Parts Made from Steel Turnings by Compressing, Sintering and Forging. *Steel, 108,* No. 21, 76, 78, 94 (1941). Bearing lock sleeves in Chevrolet cars are made of steel chips reduced to granular particles, which are then pressed, sintered and finally densified by hot-forging. Process,developed by H. Tormyn, is used on an industrial scale.

(2151) Iron Powder. A. H. Allen, *Steel, 109,* No. 14, 58-59, 90 (1941). A practical application of forging is demonstrated in the manufacture of bearing lock sleeves from sintered steel.

(2152) Wire-Making Experiments With Sintered Copper. C. G. Goetzel, *Wire & Wire Products, 16,* No. 4, 217-222, 239; No. 5, 274-278 (1941). Wires were produced from sinter compacts made from different powders. Properties of the wires are reported.

(2153) Some Experiments in Hot Forging of Iron Powder Briquettes. R. P. Koehring. *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 27, pp. 304-309. Four different raw materials subjected to identical procedure, involving compaction, sintering, and hot die-forging immediately subsequent to sintering. Tensile tests of reduced iron powder and decarburized steel powder type materials correlated.

(2154) Sintered, Forged and Rolled Iron Powders. C. G. Goetzel, *Iron Age, 150,* No. 14, 82-92 (1942). Raw materials and procedure of compaction, sintering, hot-forging and cold-rolling are described.

(2155) Iron Powder Substituted for Bronze. A. F. Macconechie, *Steel, 110,* No. 11, 98, 100, 117 (1942). Iron ring from steel scrap by hot die forging described.

(2156) Metal Working in Powder Metallurgy. C. G. Goetzel, *Wire & Wire Products, 18,* No. 6, 329-30, 355; No. 7, 394-95; No. 8, 457-58 (1943). I. Plastic deformation and powder metals. II. Industrial practices in the sintered refractory metal field. III. Cold and hot working experiments with sintered iron and copper.

(2157) Production of Sintered Bodies through Die Forging. K. Marquardt, *Metallwirtschaft, 23,* No. 40-43, 377-79 (1944). A new procedure consists of static pressing of a well-mixed powder at gradually increasing pressure in a hydraulic

press until it is sufficiently stable to withstand handling during ejection, placing into a furnace, heating, and placing into the die which is preheated to 100-300° C. (210-570° F.).

(2158) Tungsten and Molybdenum Wire Manufacture. I. H. Such, *Steel, 116,* No. 13, 90-1, 110 (1945). Production of tungsten and molybdenum powders at Wickwire Spencer Metallurgical Co. and processing steps leading to wire production.

(2159) Effect of Working on Physical Properties of Molybdenum. J. W. Marden and D. M. Wroughton, *Trans. Electrochem. Soc., 89,* 217-228 (1946). Effect of working on hardness, tensile strength and elongation of Mo is presented in form of graphs.

(2160) Fabrication of Tungsten Wire. S. Schein and J. W. Forbes, *Wire & Wire Products, 22,* 767 (1947). A discussion of processes followed in production and fabrication of tungsten wires.

(2161) Mechanical Working of Tantalum. R. H. Myers, *Metallurgia, 39,* No. 1, 7-10 (1948). The techniques for swaging, rolling, drawing of sintered bars of Ta are described. The dies in the wire drawing were of W carbides and diamonds, and the rods are heated and lubricated with a hot solution containing soft soap and tallow.

7. SUBSEQUENT TREATMENTS

A. Heat Treatments (annealing, hardening)

(2162) Quench Aging of Steel. J. H. Andrew and E. M. Trent, *J. Iron Steel Inst. (London), 138, II,* 241P (1938). Heat treatment of alloys from carbonyl iron powder are included in discussion.

(2163) Maximum Carbon in Gas Carburizing. G. H. Boss, *Metal Progress, 50,* No. 4, 657-58 (1946). It is shown that sintered compacts permit the determination of the maximum carbon content attainable in carburizing since the mass of metal in the compact is small in relation to the exposed surface.

(2164) Notes on Copper-Base Compacts and Certain Compositions Susceptible to Precipitation Hardening. F. R. Hensel, E. I. Larsen and E. F. Swazy, *Trans. Am. Inst. Mining Met. Engrs., 166,* 533-547 (1946). Heat treatment of a number of alloys is described.

(2165) Carbusintering of Iron Powders. A. S. Margolies, *Iron Age, 157,* No. 9, 60-63 (1946). Iron powder is compacted at various pressures and then carburized and sintered simultaneously.

(2166) Heat Treating Carburized Sintered Steel. G. Stern and J. Greenberg, *Iron Age, 157,* No. 17, 56-61 (1946). An investigation was made to determine the effects of various carburizing methods and subsequent heat treatment on the depth, hardness, and microstructure of different types of sintered steel.

(2167) Case Hardening of Sintered Steel. G. Stern and J. Greenberg, *Powd. Met. Bull., 1,* No. 2, 18-23 (1946). Material, metallographic results; hardness measurements; tables and micropictures.

(2168) Annealing Temperature and Hardness of Tantalum. J. W. Greenwood and R. H. Myers, *Nature, 160,* 675 (1947); *Met. Powd. Rept., 2,* No. 4, 53 (1947). Curve shows effect of annealing and cooling rate on hardness.

(2169) Liquid Carburizing of Sintered Steel. G. Stern and J. Greenberg, *Powd. Met. Bull., 2,* No. 4, 85-89 (1947). Sintered steels can be hardened to yield file hard cases with liquid carburizers at 790-840° C. (1450-1550° F.). Very shallow cases can be obtained, and bright finished sintered steel parts.

B. Impregnation Treatments (with metals or non-metals)

(2170) On Synthetic Metal Bodies – V. P. Melchior, *Z. Metallkunde, 21,* No. 1, 22-3 (1929). Discussion of paper by F. Sauerwald and J. Hunczek on new experiments in the preparation of synthetic forms from metal powders, involving the impregnation of porous iron bodies with molten copper.

(2171) Cemented Steels Are Perfected. *Business Week,* No. 873, 50-54 (1946). Latest advances in powder metallurgy involves infiltration of molten Cu into compact formed by pressing iron particles. Process perfected by American Electro Metal Corp. uses low-cost materials, provides parts of high density.

(2172) Sinteel G . *Metal Treatment, 13,* 140-1 (1946). Application of infiltration technique for high-strength products made of steel or iron cemented with Cu alloy. Discussion of article by F. P. Peters, *Materials and Methods, 23,* No. 4, 987-991, on process initiated by P. Schwarzkopf, and developed by C. G. Goetzel and R. L. Pettibone.

(2173) Sinteel G. C. Dinsdale, *Metal Treatment, 13,* No. 46, 140-41 (1946). Production technique of infiltrating porous sintered iron and steel parts with molten copper and copper alloys are described.

(2174) Cemented Steels - Infiltration Studies with Pure Iron and Copper Powders. C. G. Goetzel, *Powd. Met. Bull., 1,* No. 3, 37-43 (1946). Processing, *i.e.*, compacting, infiltration and sintering, subsequent heat treatment are described; properties given in tables and in micropictures; mechanism of sintering and infiltration is discussed.

(2175) Cemented Steels. E. S. Kopecki, *Iron Age, 157,* No. 18, 50-54 (1946). A new development in powder metallurgy may remove present-day limitations of powder metallurgy of iron and steel. Complicated shapes of high strength and density can now be produced utilizing low pressures and an infiltration method developed by C. G. Goetzel at the American Electro Metal Corp., Yonkers, N.Y.

(2176) Cemented Steels – A New High-Strength Powder Metallurgy Product. F. P. Peters, *Materials & Methods, 23,* No. 4, 987-991 (1946). Production technique involving infiltration of copper into steel sponges, and its development by engineers of American Electro Metal Corp.; characteristics of material with table of physical properties, field of use.

(2177) Improved Engineering Properties of Parts Made from Iron Powders. C. G. Goetzel, *Product Eng., 18,* No. 8, 115-9 (1947). Use of Cu alloys for infiltrating the pores is described.

(2178) Synthetic Alloys with Hard Skeleton. R. Skorski, *Hutnik, 15,* 116-120 (1948). Formed by a hard skeleton, *e.g.*, iron sponge, filled out with a soft metal possesses a higher bending strength than the same alloy without skeleton. Cu powder is sintered and impregnated with Pb for bearings or propellors. Admixture of Cr to the impregnating metal makes it corrosion proof at high temperatures.

(2179) Manufacture and Properties of Novel Sintered Alloys. R. Kieffer and F. Benesovsky, *Berg- u. Hüttenmänn. Monatsh., 94,* No. 8/9, 284-94 (1949). Impregnation alloys are prepared by impregnating a porous sintered metallic compact with a liquid metal or alloy. The paper includes a table of possible binary compositions, tables of properties of Cu-impregnated sintered iron and steel.

(2180) Refractory Metal Reenforced Super Alloys. J. M. Krol and C. G. Goetzel, U. S. Air Force, Air Materiel Command, Wright-Patterson Air Force Base, Dayton, Ohio. *AF Technical Report No. 5892,* May 1949. The technique of infiltration is applicable to the comparatively low melting corrosion resistant nickel-base or cobalt-base alloys, and spongy skeleton bodies of Mo, W, WC, TiC, W-Ti double carbide, or chromium boride. The mechanism of the infiltration process depends on the specific metallurgical and chemical conditions prevailing in the various systems.

(2181) Improvement of Sintered Metal by Artificial Resin. W. Schöning, *Die Technik, 4,* 168 (1949). Resistance to corrosion is improved by immersion in artificial resin.

C. Surface Treatments (coating, spraying, plating, atmosphere treatment)

(2182) Powder Metallurgy and Its Relation to Electroplating Industry. J. F. Kuzmick, *Proc. 31st Ann. Convention, Am. Electroplater's Soc.*, 1943, pp. 39-41. Electroplating of powder metallurgy products to facilitate the welding to the backing material, and electroplating protecting coatings for corrosion prevention.

(2183) Chrome Plating Carbide Tipped Tools. A. W. Ehlers, *Tool and Die J., 11*, No. 6, 98-100, 130 (1945). The plating equipment used was the standard sulfate bath type using lead anodes; the tools to be plated must be clean of grease, cutting and lapping compounds.

(2184) The Phosphate Treatment of Sintered Iron. *Metalloberfläche, 2*, No. 8, 173-4 (1948). The phosphate treatment makes the whole part corrosion resistant.

(2185) How to Plate Pressed Metal Powder Parts. E. A. Anderson, *Materials & Methods, 30*, No. 2, 55-57 (1949). Powder metallurgy parts can sometimes be finished for plating by barrel polishing with sawdust or buffing with greaseless compounds. In many instances, coining is advisable to eliminate the larger defects. Brass pressings, if free from pits, may be plated directly with nickel, but usually a thick copper coating should first be applied and then buffed. Recommended plating practices are based on investigations by New Jersey Zinc Co.

(2186) Plating of Pressed Metal Powder Parts. A. K. Graham, H. L. Pinkerton, E. A. Anderson and C. E. Reinhard, *Plating, 36*, No. 7, 702-9 (1949). Results of exploratory study initiated by New Jersey Zinc Co. to develop and evaluate plating techniques for powdered metal products; effect of mechanical treatments on surface porosity, based upon drag-out test is shown; procedures employed to reduce spotting out, and outdoor exposure tests on plated metal powder compacts are described; tentative plating cycles are suggested.

(2187) Steam Atmosphere Used to Heat Treat and Improve Surface Properties. F. L. Spangler, *Materials & Methods, 29*, No. 5, 56-58 (1949). Many ferrous and non-ferrous materials can be processed at temperatures up to 540° C. (1000° F.) in steam atmosphere to produce a thin, clean and tenacious oxide film on surface; steels, cast iron, sintered iron from powder, beryllium copper, brass and Al alloys have been successfully treated.

8. FINISHING, JOINING, TESTING, AND MAINTENANCE OF PRODUCTS

(2188) Grain Size Measurement. Z. Jeffries, *Chem. & Met. Eng., 18*, 185 (1918). A method is developed for the determination of grain size of tungsten.

(2189) Metallographic Examination of Very Hard Alloys. K. Schröter, *Z. Metallkunde, 20*, No. 1, 31-33 (1928). Microphotographs show the great differences in hard metals in relation to porosity and texture.

(2190) Sensitive Reaction for the Discovery of Molybdenum. J. V. Tamchyna, *Chem. Listy, 24*, 465-466 (1930). A very sensitive analytical method for the detection of small quantities of molybdenum in tungsten is given.

(2191) Preparation of Microsections of Tungsten Carbide. S. L. Hoyt, *Trans. Am. Soc. Steel Treating, 17*, 54-58 (1931). The paper discusses a method of preparing cemented tungsten carbide for metallographic examination.

(2192) Border Regions of Metallography. K. Schröter, *Z. Metallkunde, 23*, No. 7, 197-201 (1931). A metallographic method of mounting tungsten filaments is described, and the recrystallization phenomena of the wires are studied.

(2193) Alkaline Solution of Potassium Cyanide for Etching of Tungsten. J. A. M. van Liempt, *Rec. trav. chim., 52,* 425 (1933). A very strong etching solution of potassium cyanide is recommended to develop well-marked crystalline facets on single crystal tungsten wire or bars.

(2194) Mode of Action of Etching Reagents for Carbides. R. Mitsche, *Arch. Eisenhüttenw., 9,* 311-312 (1935). Study of combined action of hydroxyl ions and oxidizing agents in the conventional etching reagents for carbides.

(2195) Metallurgical Progress and the Finishing Industry. L. Sanderson, *Synthetic and Applied Finishes, 6,* 294-5 (1935). Refers in part to powder metallurgy products.

(2196) Cemented Carbides as Used in Metal Cutting Tools. *Am. Machinist, 83,* No. 5, 127-34 (1939). Tool supports and holders, and methods of tip brazing and grinding practice are described.

(2197) A Sensitive Pyramidal-Diamond Tool for Indentation Measurements. F. Knoop, C. G. Peters and W. B. Emerson, *J. Research Natl. Bur. Standards, 23,* 39-61 (1939). A new type of microhardness tester is described.

(2198) Examination of Metals and Hard Metals Using a Hard Metal Disk. N. Sawin, *Werkstattstechnik Werksleiter, 33,* No. 6, 165-170 (1939). Abrasion testing of materials is performed by measuring a notch which is worn into the material by a hard metal disk.

(2199) Determination of Co and Ni in Green and Sintered Compacts with Tungsten Carbide Base. V. G. Shcherbakov, *Zavodskaya Lab., 8,* 389-90 (1939). The following methods are used: *(1)* Calcine sample to destroy the carbides and oxidize W and Co; separation of Co and Fe from W by precipitation with NH_3; filter and electrolyze filtrate for Co. *(2)* Treat sample with HF and follow this with dropwise addition of HNO_3 to destroy carbides; the precipitated Co and Fe is dissolved in HCl; Fe precipitated with NH_3 and Co determined in filtrate by electrolysis.

(2200) A Microhardness Tester. H. Hanemann and E. O. Bernhardt, *Z. Metallkunde, 32,* 35-38 (1940). The applications of a new type of microhardness tester are described. Sintered porous metals (iron) and hard alloys can be tested.

(2201) Hardness Conversion Relations. H. Scott and T. H. Gray, *Trans. Am. Soc. Metals, 28,* 399-423 (1940). A conversion chart relating to sintered carbides *(e.g.,* of the Firthite type) is presented.

(2202) Hardness Conversion for Hard Metals. H. Scott and T. H. Gray, *Iron Age, 145,* No. 23, 39-41 (1940). Conversion equations for testing the hardness of steel and cemented carbides.

(2203) Potentiometric Determination of Cobalt in Cemented Carbide Compositions. V. G. Shcherbakov and T. S. Kholcheva, *Zavoskaya Lab., 9,* 827-30 (1940). Development of a new method for Co in cemented carbides based on potentiometric titration with potassium ferricyanide solution in presence of W, Fe, Zn.

(2204) How To Finish Carbide Drawing Dies. *Iron Age, 147,* No. 5, 48 (1941). Brief note on development of complete line of equipment for finishing and servicing as announced by Carboloy, Inc.

(2205) Microhardness of Solids. E. O. Bernhardt, *Z. Metallkunde, 33,* 135-44 (1941). The development of a microhardness tester with a high resolution capacity is described. Of interest is the testing of powder and porous sintered materials.

(2206) Apparatus for the Investigation of Thermomechanics and Micromechanics of Metals. P. Chevenard, *Rev. Mét., 38,* No. 12, 317-334 (1941); *39,* No. 2, 33-53; No. 4, 123-128 (1942). A description of the apparatus which is suitable for mechanical testing of very small specimens, *e.g.,* those readily produced in powder metallurgy.

(2207) Titanium-Tungsten Carbide Cutting Tool Analyses. J. W. Jones, *Chem. Age (London), 45,* No. 1155, 91-2 (1941). Description of preparation of samples, methods of analysis, with special reference to analysis for iron content.

(2208) Performance of Diamond Impregnated Grinding Wheels. G. Pahlitzsch, *Schleif- und Poliertechnik, 18,* 39-55 (1941); *Chem. Zentralblatt, 112,* II, 94 (1941). The grinding behavior of Widia cemented carbide is studied in connection with different types of diamond wheels.

(2209) Grinding Carbide Tools. R. A. Reed, *Machine Tool Blue Book, 37,* No. 1, 33-52 (1941). Silicon carbide wheels and diamond wheels are described.

(2210) Determination of the Micro-Hardness of Metals. F. Schulz and H. Hanemann, *Z. Metallkunde, 33,* 124-34 (1941). Description of a microhardness tester as a tool for the determination of the hardness of individual crystallites and particles.

(2211) Brazing Carbide Tips on Tools. *Automotive Ind., 86,* No. 1, 25, 80 (1942); *Industry and Welding, 15,* No. 1, 24 (1942). Torch brazing procedure is described.

(2212) Brazing Carbide Tips. C. Cleveland, *Hitchcock's Machine Tool Blue Book, 38,* No. 2, 115-16 (1942). An unusual and speedy brazing set up has been devised, which permits the use of City gas instead of oxy-acetylene.

(2213) A Microhardness Tester. H. Hanemann, *Metallwirtschaft, 21,* 315-20 (1942). A description is given of a new type of microhardness tester, and its use is described. Of interest for the testing of porous sintered metals.

(2214) Detection of Lead in Steel and in Sintered Iron-Lead Powder Products by Metallographic Means. K. E. Volk, *Archiv Eisenhüttenw., 16,* No. 2, 81-84 (1942). Etching method for sintered Fe-Pb powder compacts described.

(2215) Electronic Induction Equipment Developed for Routine Brazing of Carbide Tools. *Ind. Heating, 10,* No. 9, 1308, 1310 (1943); *Machine Tool Blue Book, 39,* No. 6, 185-6, 188 (1943). Commercial announcement by Carboloy Co., Inc., of availability of electronic induction equipment for brazing of carbide tools onto steel shanks.

(2216) Turning Tools with Hard Metal Tips. W. Dawihl and J. Hinnüber, *Werkstattstechnik, 37/22,* No. 11, 393-6 (1943). Testing a hard metal tip having 15% less tungsten than usual is described.

(2217) Carbide Tools Tipped by Induction Brazing. P. Miller, *Am. Mach., 87,* No. 21, 106-107 (1943). Step-by-step account of procedure illustrated.

(2218) Polishing Tungsten Carbide. R. W. Nothnick, *Metals & Alloys, 18,* No. 3, 538 (1943). An inside polishing wheel employing diamond dust to polish W carbide.

(2219) Hardness Scales. K. Rose, *Metals & Alloys, 18,* No. 6, 1353 (1943). The position of various materials of construction and hard substances is shown on Mohs' and the conventional engineering scales.

(2220) The Micro-Hardness Tester — A New Tool in Powder Metallurgy. R. Steinitz, *Metals & Alloys, 17,* No. 6, 1183-1187 (1943). Tester described which overcomes difficulty of testing powder metallurgy parts of duplex structure.

(2221) Diamond Die Maintenance. *Industrial Diamond Rev., 5,* 145-47 (1945). Methods used for the reboring and polishing of diamond dies and sintered carbide dies for wire-drawing vary widely. Suggestions are given for guidance.

(2222) Improved Method of Brazing Carbide Tips to Shanks. *Machinery (N.Y.), 52,* No. 2, 192 (1945). The main body of steel under the tip is not heated, so that it does not expand as much as the tip.

(2223) Standard Packing of Carbide Tools. *Screw Machine Engineering, 6,* No. 4, 77-78 (1945). Carboloy Co. has standard packing program for shipment of tools and tips in various quantities.

(2224) Brazing Carbide Tips. R. O. Catland, *Western Mach. & Steel World, 36,* 486-492 (1945). Different methods are used in the brazing of cemented carbide tips to cutter bodies.

(2225) Macropore-Size Distribution in Some Typical Porous Substances. L. C. Drake and H. L. Ritter, *Ind. Eng. Chem., Anal. Ed., 17,* No. 12, 787-791(1945). Measured porous substances including porous Fe.

(2226) Calculatory Methods for Economic Repolishing of Sintered Carbide Dies. P. Grodzinski, *Wire Ind., 12,* No. 141, 469-70 (1945). Gives a mathematical treatment of the problem of how much should be removed in axial and radial direction of used die.

(2227) Apparatus for Measurement of Density of Porous Solids. K. A. Krieger, *Ind. Eng. Chem., Anal. Ed., 17,* No. 8, 532 (1945). The apparatus described by the same author in *Ind. Eng. Chem., Anal. Ed., 16,* No. 6, 398 (1944) is also convenient for the measurement of density of porous solids with helium as displaced fluid.

(2228) Preventing Cracks in Cemented Carbide Tools. W. Newcomer, *Hitchcock's Machine Tool Blue Book, 41,* No. 7, 281-82 (1945). A new method of brazing cemented carbide tips to tool shanks is described.

(2229) Pore Size Distribution in Porous Materials. H. L. Ritter and L. C. Drake, *Ind. Eng. Chem., Anal. Ed., 17,* No. 12, 782-786 (1945). A method for determining the macropore-size distribution in a porous solid, as well as the derived distributions for some typical porous materials is presented.

(2230) Metallography of Cemented Carbides. D. H. Shute, *Metal Treatment, 12,* 13-18, 37 (1945). Diamond and boron carbide are the only two available abrasives which besides being angular in shape are appreciably harder than carbide itself, so that they can be used for preparation of microsections.

(2231) How the Russians Lap Carbides. *Am. Machinist, 90,* No. 7, 138 (1946). An operating cycle of 1.5 hours is sufficient to lap a large number of carbide inserts glued to the upper removable disk of a lapping apparatus.

(2232) Air Permeability Tester for Porous Sheet Materials. *Mach. Design, 18,* No. 12, 155 (1946). Arrangement of components and functioning of "Permeometer" shown in schematic drawing.

(2233) Brazing Tool Tips by Induction Heating. *Steel, 119,* No. 8, 101, 154 (1946). Tungsten carbide tips are brazed to more than 200 types of cutting tools by induction heating. Discussion of reduction of costs.

(2234) Induction Brazing of Carbide Tools. *Western Metals, 4,* No. 7, 25-27 (1946). The induction heating eliminates removal of excess of metal from the shank of tool, and reduces wear on the finish grinding wheels by elimination of the wiring on tip.

(2235) Economies of Milling with Carbide Tipped Cutters. C. H. Bodner, *Western Mach. & Steel World, 37,* No. 1, 14-15 (1946). Carbide tipped cutters can be sharpened by grinding only the peripheral cutting edge and the corner radius.

(2236) Cushions for Carbides. A. W. Ehlers, *Tool & Die J., 12,* No. 4, 80-83 (1946). A copper sandwich braze was effective in partially dampening vibrations and prevented tip failure.

(2237) Geiger Counter Used in Powder Metallurgy. E. S. Kopecki, *Iron Age, 157,* No. 9, 48-51 (1946). Tungsten carbide and other hard substances can be estimated by x-ray diffraction analysis using the Geiger-Muller counter for measuring the intensities of the reflections from the x-ray spectrometer.

(2238) Corrosion Tests on Sintered Projectiles from Iron Powder. Metallgesellschaft A. G., Frankfurt a/Main. F. D. Rept. No. 1312/46 (1946). Tumbling in zinc powder improved the resistance to atmospheric corrosion of bonderized sintered iron parts, but had no effect on non-bonderized parts. Report dated 1944.

(2239) Tests on Iron Powder in 1940. Metallgesellschaft A. G., Frankfurt a/Main. F. D. Rept. No. 1318/46 (1946). Hydrogen-reduced iron powder (origin not stated) gave sintered rings of low strength and hardness, but excellent forgeability.

(2240) Mounting Porous or Scaled Specimens. E. Simister, *Metal Progress, 49,* No. 1, 128 (1946). A special metallographic mounting technique is described whereby the porosity pattern is brought out fully for microscopic examination.

(2241) Machining Powder-Metal Parts. H. L. Strauss, Jr., *Am. Machinist, 90,* No. 7, 137 (1946). Some suggestions on machining of powder metal parts, *e.g.*, boring, drilling, reaming, milling.

(2242) Gas Welding of Sintered Iron. Vereinigte Deutsche Metallwerke. F. D. Rept. No. 2524/46 (1946) (formerly H.E.C. 12388). Welding of piston rings with a neutral oxyacetylene flame. Dated 1942.

(2243) Induction Heating Brazes Tool Tips. T. A. Vernor and E. F. Adams, *Welding Eng., 31,* No. 3, 53 (1946). Silver brazing plus induction heating speeds up the job of replacing worn tungsten cutting tips on a steel shank.

(2244) Sawing of Hard Metals. C. H. Wick, *Machinery (N.Y.), 52,* No. 10, 169-171 (1946). The principles and applications in the hard metal field of friction hard-sawing are discussed.

(2245) Sawing of Hard Metals. C. H. Wick, *Mach. moderne (France), 40,* 343-46 (1946). Principles and applications of friction hard-sawing are described.

(2246) "Grinding" Carbide Tools by Electric Arc. *Machinist (London), 91,* 872 (1947). A process of grinding carbide tips by electric arc is said to give longer life to the tools.

(2247) Spot Welding of Titanium. R. S. Dean, J. R. Long, E. T. Hayes, and D. C. Root, *Trans. Am. Inst. Min. Met. Engrs., 171,* 431-8 (1947). The shear strength of Ti welds is considerably greater than the values required in light metals and is about the same as steel of comparable strength.

(2248) Carbide Structures in Carburized Thoriated-Tungsten Test Filaments. C. W. Horsting, *J. Applied Phys., 18,* 95-99 (1947); *C. A., 41,* No. 8, 1973 (1947). The thyratron relay method of carburizing control is reviewed and is considered excellent. Solid and laminated carburized structures in test filaments were produced.

(2249) Iron Powder Compacts and Powders for Microscopic Examination. H. Jamison and E. S. Bryon, *Metal Progress, 51,* No. 3, 437-444 (1947). Sampling and sectioning, mounting, grinding, final polishing, photomicrographs, of finished compacts.

(2250) Testing Mechanical Properties of Sintered Raw Material. W. Jung-Koenig and G. Wassermann, *Metallforschung, 2,* No. 7/8, 244-49 (1947). The mechanical properties of sintered samples from Fe powder were determined. The determination of the impact sensitivity is of special significance for porous sinter material. The values obtained for hot-pressed material with 98% by volume of Fe were not lower than those of compact material.

(2251) Metallographic Evaluation of Surface Coating. H. Klemm, *Metall, 1,* 79-80 (1947). Sections are taken at an acute angle to the surface instead of normal to it. Formulas are given for calculating the actual layer thickness for the measured layer cut at a given angle.

(2252) Electrolytic Method for Pointing Tungsten Wire. W. G. Pfann, *Trans. Am. Inst. Mining Met. Engrs., 175,* 606-610 (1947). Electropointing method is simple and rapid and requires elementary apparatus.

(2253) Cutting Tests with Widia Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3719/47 (1947). Tests are described in report dating from 1932.

(2254) The Leyensetter Cutting Test. Studiengesellschaft Hartmetall. F. D. Rept. No. 3720/47 (1947). This report of 1932 describes a special test for hard metals.

(2255) Cutting Tests with Tungsten Carbide-Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3723/47 (1947). Tests performed with tungsten-titanium double carbide hard metal grades were reported in 1932.

(2256) Cutting Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3730/47 (1947). Successful tests were made at Krupp in 1933 on hard metal tips of different compositions made by Gebr. Böhler.

(2257) Cutting Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3731/47 (1947). Highly favorable cutting tests on steels with vacuum-sintered Osram-X and Osram-Y were reported in 1933.

(2258) Hard Metal Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3733/47 (1947). Test and analysis of hard metal specimens, supplied by Krupp, made and reported in 1935.

(2259) Diamond Powder. Studiengesellschaft Hartmetall. F. D. Rept. No. 3734/47 (1947). A lengthy report, dating from 1935, with English translation, on the cleaning, crushing and grading of diamond powder, to be used for grinding and lapping of hard metal tools.

(2260) Hard Metal Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3735/47 (1947). Cutting tests with hard metal on various materials for development purposes were made and reported in 1935.

(2261) Diamond Powder for Finishing Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3736/47 (1947). Improved lapping with narrow size fractions of diamond powder and silicon carbide was reported in 1935.

(2262) Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3738/47 (1947). Instructions for making chemical analyses of sintered hard metals date from 1938.

(2263) Diamond Dust. Studiengesellschaft Hartmetall. F. D. Rept. No. 3744/47 (1947). Waste diamond dust was bought very cheaply and purified with a roughly 75% yield in 1936. To be used for grinding and lapping hard metal tools.

(2264) Testing of Cutting Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3749/47 (1947). This report of 1935 recommends that in cutting tests accelerated speeds should be avoided as temperature increases produce secondary effects. The entire problem of tests should be investigated and correlated with practice.

(2265) Carbides for Grinding and Polishing Dies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3754/47 (1947). Boron carbide, boron, tungsten carbide and silicon carbide were found in 1936 to be equally useless for grinding or polishing diamond dies. In polishing tungsten carbide dies, boron carbide was half as effective as diamond powder, boron slightly less effective, and silicon carbide about one-fifth as effective. For grinding carbide dies, however, boron carbide was four times better than silicon carbide and should, therefore, be used in preference to diamond powder. Instructions for recovering diamond dust sweepings are given in the same report.

(2266) Etching of Cemented Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3769/47 (1947). Electrolytic etchings to determine occurrence of cobalt in WC-Co are reported in 1937.

(2267) Testing Metal Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3837/47 (1947). Hardness measurements on WC-Co tips are reported in 1940.

(2268) Hard Metal Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3838/47 (1947). Apparatus for measuring the modulus of elasticity of hard metals from bending tests is described in report dating from 1940.

(2269) Tests on Hard-Facing Materials. Studiengesellschaft Hartmetall. F. D. Rept. No. 3874/47 (1947). Metallographic tests on various Krupp hard-facing materials, *e.g.*, Verdur, Verdur 3, Carbon, Diaweld and Diaweld B are described.

(2270) Plant for Recovery of Carbide Scrap. Studiengesellschaft Hartmetall. F. D. Rept. No. 3875/47 (1947). Detailed estimates, dated 1941, for building a 5 ton/month plant for the recovery of metals from carbide scrap by the nitrite process.

(2271) Part 2. Grinding Machine for Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3878/47 (1947). An automatic grinding and polishing machine is described in this report of 1941, with comparative results by a manual test.

(2272) Grinding of Tungsten Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3883/47 (1947). According to this report of 1941, automatic grinding and polishing shows up less porosity than the manual method.

(2273) Cutting Tests on Titanium Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3906/47 (1947). Metallography and cutting tests on TiC-VC bonded with Fe-Ni-Cr_3C_2, dating from 1942.

(2274) Specific Gravity Measurements. Studiengesellschaft Hartmetall. F. D. Rept. No. 3919/47 (1947). According to this report of 1942, specific gravity measurements should be done on samples weighing less than 10 g. in xylol, between 10-20 g. in either xylol or water, and more than 20 g. in water.

(2275) Boron Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3921/47 (1947). Boron carbide ground to 0.5 micron and made into a paste gave a good polish on hard metal, according to report dating from 1942.

(2276) Regrinding Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3928/47 (1947). Instructions for regrinding carbide tips in munition factories, first with silicon carbide and then with boron carbide, dating back to 1942.

(2277) Cutting with Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3931/47 (1947). Cutting tests and performance of various WC-free hard metals were reported on in 1943.

(2278) Cutting Tests with Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3932/47 (1947). Cutting tests on WC-Co and WC-TiC-Co tips of modified economy design were reported in 1943.

(2279) Cutting Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3938/47 (1947). Cutting tests on Titanit and Böhlerit were described in a report dating back to 1936.

(2280) Cutting Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3939/47 (1947). Cutting and metallographic tests on 95:5 TiC-Co were reported in 1943.

(2281) Metallographic Tests on Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3941/47 (1947). Metallographic tests to show zoning in carbon-deficient TiC are described in report dating back to 1943.

(2282) Brazing Tests. Studiengesellschaft Hartmetall. F. D. Rept. No. 3948/47 (1947). Brazing tests on TiC-containing hard metal were reported in 1944.

(2283) Etching. Studiengesellschaft Hartmetall. F. D. Rept. No. 3949/47 (1947). Etching with hydrogen peroxide to reveal the β- and δ-phases in cemented carbides is described in a report dating back to 1939. A second report of 1943 gives etching agents for binders other than Co. Etching agents for revealing carbon-deficient phases with various binders are given in a third report of 1944.

(2284) Silicon Carbide Wheels. Studiengesellschaft Hartmetall. F. D. Rept. No. 3957/47 (1947). Estimate for silicon carbide wheels required for grinding 10 tons of carbide tips in 1944.

(2285) Metallographic Tests on Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3960/47 (1947). Metallographic tests on W-free hard metals made by Metallwerk Plansee and Böhler are described in report dating back to 1944.

(2286) Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3963/47 (1947). Report on automatic grinding of carbide tips of 1944.

(2287) Brazing of Hard Metal. Studiengesellschaft Hartmetall. F. D. Rept. No. 3970/47 (1947). Brazing of TiC-base hard metal by preliminary treatment with copper sulfate solution, followed possibly by copper-plating, is described in report of 1945.

(2288) Determination of Knoop Hardness Numbers Independent of Load. L. P. Tarasov and N. W. Thibault, *Trans. Am. Soc. Metals, 38,* 331-53 (1947). Hard materials such as boron carbide, silicon carbide, and cemented tungsten carbide, type Kennametal KM, are used in the investigation, and it was found that elastic recovery of the substance upon load removal must be compensated for.

(2289) Measured Knoop Hardness of Hard Substances and Factors Affecting Its Determination. N. W. Thibault and H. L. Nyquist, *Trans. Am. Soc. Metals, 38,* 271-330 (1947). The conditions are specified under which a determination

of the Knoop hardness number on the Tukon tester should be carried out. Data are given for cemented carbides and other hard substances.

(2290) Attack Method for Preparing Tungsten. H. W. Woods, *Metal Progress, 51,* No. 2, 261-63 (1947). A new metallographic method for the preparation of tungsten wire specimens is described and illustrated, whereby polishing and etching is done simultaneously.

(2291) Hot Hardness Testing. O. Zmeskal, *Metal Progress, 51,* No. 1, 86 (1947). The results are given of an investigation of the variation of hardness with temperature for an alloy of tungsten carbide with 12% cobalt. Apparatus was developed by E. C. Bishop and M. Cohen.

(2292) Sharpening of Cemented Carbide Tools by the Electro-Erosion Spark Discharge Process. B. N. Zolotykh, *Stanki i Instrument, 18,* No. 3, 23-24 (1947). Experimental study of most favorable conditions for grinding of cemented carbide (WC + 8% Co) tipped tools by the electro-erosion spark discharge process is reported. The process is in wide commercial use in Russia and requires but slight changes on existing machine tools. Data on experimental grinding setup are given.

(2293) Drilling Very Hard Materials. *Metal Progress, 53,* No. 11, 686 (1948). The necessary equipment consists of a drill press, some diamond powder, and a short piece of copper tubing of proper diameter, which is slotted with a hack-saw. Method is used in finishing cemented carbides.

(2294) Test Developed for Metal Powder Products. *Steel, 122,* No. 16, 116 (1948). Non-destructive testing of porous metal powder products may be accomplished prior to the firing with a method developed by Magnaflux Corp.

(2295) Carbide Die Construction. *Steel, 123,* No. 23, 115, 157 (1948). Diamond boring is used on dies with one or more radii which would be difficult to produce with a straight diamond wheel.

(2296) Carbide Die Construction. *Tool & Die J., 14,* No. 3, 64, 66 (1948). Diamond boring, grinding and lapping are discussed.

(2297) New Diamond Wheel Recommendations for Carbide Grinding. F. J. Benn, *Grits and Grinds, 39,* No. 8, 1-5 (1948). In order to obtain benefits of lower cost and faster grinding time, certain fundamental operating rules should be observed; table of wheel recommendations.

(2298) Application of Micro-Hardness to Sintered Alloys. H. Bückle, *Met. Powd. Rept., 3,* No. 1, 6 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 185 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 19. After discussing the theory of micro-hardness the author shows that it can be extrapolated to macro-hardness, as confirmed for Al and Fe. Micro-hardness measurements were important for investigating diffusion and micro-impregnation, in the form of comparison measurement. The method surpasses other methods in its sensitivity.

(2299) Color Metallography. W. D. Forgeng, *Iron Age, 162,* No. 16, 130-33 (1948). The use of color metallography is advantageous in alloys containing carbides and in grain size determinations.

(2300) Structures of Hard Metal Alloys. H. Franssen, *Arch. Eisenhüttenw., 19,* 79-84 (1948). Etching techniques and qualitative structural examination are reported.

(2301) Analysis of Simple and Complex Tungsten Carbide. J. J. Furey and T. R. Cunningham, *Ind. Eng. Chem., Anal. Ed., 20,* 563-70 (1948). Details of analytical methods used for cemented tungsten carbide are described.

(2302) Machining High Purity Molybdenum. J. Gelok, *Iron Age, 162,* No. 24, 106-110 (1948). Because of its inherent characteristics some unusual problems are faced in machining, forming and joining Mo.

(2303) An Appraisal of Testing Methods for Sintered Metals. C. G. Goetzel, *Met. Powd. Rept., 2,* No. 12, 191 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 184 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 53. The author stresses that the object of a test is to determine the property, knowledge or control of which is desired. The tests are divided into static and dynamic, according to the force applied. The effect of the porosity is emphasized.

(2304) Corrosion Resistance of Porous Bronze Compacts. M. M. Hallett, *J. Soc. Chem. Ind. (London), 67,* No. 1, 57-61 (1948). Tests are made on porous bronze compacts of powders to a range of acids, alkalies, salts in comparison with the resistance of solid bronze under the same conditions.

(2305) Welding High Purity Molybdenum. J. Henschkel, *Iron Age, 162,* No. 25, 87-89 (1948). Inert gas shielded arc welding and spot welding are being regularly used for joining Mo to itself and other metals. Flash and percussion welding experiments are discussed.

(2306) Grinding of Hard Metal. H. Kalpers, *Metalloberfläche, 2,* No. 8, 171-3 (1948). Grinding with wheels of silicon carbide; dry and wet grinding; re-grinding.

(2307) Metallographic Preparation of Tungsten Carbide. G. L. Kehl, *Ind. Diamond Rev., 8,* No. 11, 340 (1948). The method of sawing off a small portion by using a metal bonded diamond wheel is described.

(2308) How to Grind Carbide Die Parts. R. LeGrand, *Machinist (London), 91,* 1353-64 (1948). A detailed illustrated article.

(2309) Penetration Hardness of Solid and Porous Metal Bodies. R. Mitsche, *Met. Powd. Rept., 3,* No. 1, 6 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 186 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 35. Hardness measurement was interpreted by a formula. The poly crystalline hardness depends on the deformation of the crystal and also on the relative movement of the crystal. Microhardness refers to single crystal only, while the hardness of a polycrystalline section represents its macrohardness.

(2310) Caliper Gauge for Drawing Dies. H. Mucke, *Stahl u. Eisen, 68,* No. 25, 484 (1948). The gauge used in measuring cemented carbide dies is described.

(2311) X-Ray Examination at High Temperatures. A. Neth, *Oesterr. Chem. Ztg., 49,* No. 10/11, 185 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 41. Description of a heated holder for the test specimen, which can be used up to 1100° C. (2010° F.) and which is separated from the x-ray camera. The heater is also turnable.

(2312) Microhardness of Metals and Minerals. E. M. Onitsch, *Berg- u. Hüttenmänn. Monatsh., Montan Hochschule, Leoben, 93,* 7-12 (1948). A review is given of the different methods of testing, and microhardness values are given for crystallites and particles of a variety of metals, alloys and compounds.

(2313) Variation of the Microhardness and Meyer's Number in the Pressing and Sintering of Metal Powders. E. M. Onitsch, *Met. Powd. Rept., 3,* No. 1, 6 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 186 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 36. As micro- and macro-hardness measurements are both load-dependent, it is suggested that hardness values generally should be characterized by multiplication with a Meyer's number. The latter can provide some indication of the degree of work hardening.

(2314) Rapid Spectrographic Analysis of Cemented Carbide Compositions. J. C. Redmond, *Steel, 122,* No. 26, 86-8 (1948). Results obtained in investigation, at Kennametal, Inc., into methods of separating and quantitatively determining Co, W and C; the methods are described, eliminates sources of error by use of stable sparklike discharge.

(2315) Non-Destructive X-Ray Investigations of Microstructure of Metals and Metal Powders. F. Regler, *Met. Powd. Rept., 2,* No. 12, 191 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 185 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 40. The paper summarizes x-ray techniques and the interpretation of the results. Various remarks on grain size determination are suggestive, but otherwise the emphasis is on x-rays rather than powders.

(2316) Two Simple Methods for Determination of the Intensity of Sintering. G. Ritzau, *Oesterr. Chem. Ztg., 49,* No. 10/11, 188 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 10. *(1)* The heating of a single pressed bar in a graduated temperatures range allows measurement of the different stages of sintering in dependence of temperature during one test (*e.g.*, hardness). *(2)* Sintered composite or heterogeneous bodies having a ferromagnetic and a paramagnetic component (*e.g.*, WC-Co) show a distinct dependence of the

coercive force on the degree of sintering. Measurements are readily made in the coercimeter.

(2317) **Carbide Die Maintenance.** R. Saxton, *Metallurgia, 38,* No. 228, 314-16 (1948). Description of the production of sintered carbide dies and their maintenance in a serviceable condition.

(2318) **To the Methodic of Investigation of High Refractory, Electrical Conductive, Carbides.** F. Skaupy, *Oesterr. Chem. Ztg., 49,* No. 10/11, 188 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 8a. The author recommends the use of inert gases, *e.g.*, Hg-vapor, in the test furnace, instead of a vacuum; or the use of a direct resistance heating of long test bars in C-containing atmosphere; some results are communicated.

(2319) **Compressibility Factor.** G. B. Smith, *Metal Ind. (London), 72,* 427 (1948). High pressures beyond those used for metal powders give an expected density somewhat lower than the calculated density, caused by work hardening of powder particles, so that in effect the correction factor will have been decreased.

(2320) **Analysis of Cemented Carbide Composition.** W. O. Touhey and J. C. Redmond, *Anal. Chem., 20,* 202 (1948). Details of analytical methods used for cemented multicarbides are described.

(2321) **Corrosion Tests on Sintered Iron Bullets.** Vereinigte Deutsche Metallwerke. F. D. Rept. No. 3535/48 (1948) (formerly H.E.C. 12364). Results of a 9-day atmospheric corrosion test conducted in 1944. Bonderized and varnished samples were unaffected.

(2322) **Welding of High Melting Point Metals.** E. G. West, *Sheet Metal Industries, 25,* No. 256, 1621-26 (1948). Welding of tungsten, tantalum, titanium, and chromium is described.

(2323) **Metallographic Study of Cemented Carbides.** N. M. Zarubin, *Zavodskaya Lab., 14,* 1434-1436 (1948). Etching solutions recommended on the basis of author's results.

(2324) **Brazed Tool Tips.** *Aircraft Prod., 11,* 295-97 (1949). Non-destructive testing method developed by Bristol Aeroplane Co. Ltd.

(2325) **Manufacture of Carbide Dies.** *Machinery (N. Y.), 55,* No. 6, 170-71 (1949). Carbide dies having irregular contours should be diamond bored; grinding of dies is described.

(2326) **Die Polishing.** *Wire Ind., 16,* No. 186, 487 (1949). A diamond die with a tungsten carbide entrance cone is described.

(2327) **Sharpening Cemented Carbide Tools with Silicon Carbide Wheels.** J. C. Arndt, *Automotive Ind., 100,* No. 2, 46, 80, 82 (1949). A discussion of the defects caused by heat shock crazing and cracking.

(2328) **Developments in Carbide Grinding.** F. J. Benn, *Tool Eng., 22,* No. 2, 17-21 (1949). Use of silicon carbide wheels; selection of diamond wheels; table of wheel recommendations.

(2329) **New Diamond Wheel Recommendation for Carbide Grinding.** F. J. Benn, *Ind. Diamond Rev., 9,* No. 3, 75-77 (1949). Selection of bond and grit size are discussed.

(2330) **Preparation of Polished Specimen of Cemented Carbide.** I. N. Chaporova, *Zavodskaya Lab., 15,* 799-805 (1949). The hard metal specimen is prepared by grinding first on a silicon carbide wheel, then with boron carbide powder on a cast iron plate moistened with kerosene.

(2331) **Simple Electrolytic Polishing Procedures for Molybdenum Metallographic Specimens.** W. C. Coons, *Trans. Am. Soc. Metals, 41,* 1415-24 (1949). Photomicrographs of sintered and cast Mo are given to show benefits of a rapid technique of electropolishing in H_2SO_4 and in H_2SO_4-HCl-CH_3OH solutions. Electrolytic etching of Mo by 0.5% oxalic acid is recommended.

(2332) **Spot Welding of Titanium.** R. S. Dean, J. R. Long, E. T. Hayes, and D. C. Root, *Metal Progress, 55,* No. 2, 200, 252, 254 (1949). Titanium can be welded readily, requiring no special cleaning procedures if no heavy oxide

coatings are present. Graphs are plotted of the variables welding current, time, and tip pressure *vs.* shear strength.

(2333) Electron Micrographs of Tungsten. L. Delisle, *Metal Progress, 56,* No. 5, 670-71 (1949). Representative electron micrographs (11,000 to 18,000 diameters magnification) of tungsten are shown, and the methods of preparation and analysis are briefly given.

(2334) Oxygen in Titanium. G. Derge, *Trans. Am. Inst. Mining Met. Engrs.,* No. 10, 31-33 (1949). Proper modification of the vacuum fusion analytical procedure as ordinarily applied to steels has resulted in the satisfactory analysis of carefully prepared Ti-oxygen alloys containing up to 0.5% 0_2.

(2335) Polishing Metallographic Specimens with Diamond Dust. H. J. Grenville-Wells, *Ind. Diamond Rev., 9,* No. 109, 360-3 (1949). Methods of polishing of sintered carbides reviewed; polishing of soft metals; polishing of mineralogical specimens with diamond dust. Bibliography.

(2336) Metallography of Beryllium. A. R. Kaufmann, P. Gordon, D. W. Lillie, *Metal Progress, 56,* No. 5, 664-65 (1949). Since no satisfactory etchant for Be has been found, the specimens are examined with polarized light. The method of preparation of the samples is described. Representative photomicrographs of vacuum-cast and flake Be are shown and discussed.

(2337) G. L. Kehl, *Principles of Metallographic Laboratory Practice.* McGraw-Hill, New York, 3rd ed., 1949. On pp. 43-45, a new technique for preparing tungsten carbide specimens using appropriate grades of diamond dust instead of SiC or B_4C is described.

(2338) Polishing of Hard Alloy Blades. R. M. Kolker, *Stanki i Instrument, 20,* No. 5, 17-19 (1949). Reference is made to the use of diamond-metal wheels.

(2339) Reproducibility of Tungsten Carbide in Milling of Cast Iron. K. G. Lewis, *Iron Coal Trades Rev., 158,* No. 4227, 563-70 (1949). Test conditions are described and the usefulness of fly-cutting as basis of test is outlined.

(2340) Extending the Life of Tungsten Carbide Form Tools. C. A. McQuarrie, *Tool Eng., 22,* No. 6, 23 (1949). Using a wooden wheel with a paste of diamond dust, the edge surfaces of the tool are burnished to a mirror finish.

(2341) The Welding of Pure Molybdenum. H. J. Nichols, K. B. Young and M. J. Nolan, *Welding J., 28,* No. 5, 236-39-s (1949). The paper presents the results in welding Mo of 99.9% purity; the necessity of proper welding precautions. The pseudo-welds obtained with common processes are quite brittle.

(2342) Metallography of Zirconium and Zirconium Alloys. A. H. Roberson, *Metal Progress, 56,* No. 5, 667-69 (1949). Description of methods of preparation of specimens. Etchants containing HF are most satisfactory; 4 formulas are given. A brief discussion of electrolytic polishing and etching is given. Representative photomicrographs are shown.

(2343) Diamond Powders and Wire Die Finish. E. J. Schneider, *Wire and Wire Products, 24,* No. 6, 504-05 (1949). The concentration of the diamond powder must be the optimum for the job to give fastest performance without waste.

(2344) Metallographic Technique for Mounting Porous Compacts. R. Wachtell, *Powd. Met. Bull., 4,* No. 4, 126-8 (1949). A mounting method was developed permitting good edge preservation during mechanical preparation, even vision of microporosities at some distance within specimen; mounting medium used, temperatures and pressures are given; method works best in conjunction with diamond polishing techniques.

(2345) Machining Sintered Powdered-Metal Bearing Materials. E. J. Weller, *Machinery (N. Y.), 55,* No. 10, 181-4 (1949). General principles outlined applying to all machining operations; feeds recommended for high speed steel drills; tapping and reaming of holes in powdered metal parts and machining of porous bearing materials are described; grinding and lapping are not practical; how and when to proceed with burnishing is discussed.

(2346) Hardness of Nickel Compacts. S. R. Williams, *Metal Progress, 56,* No. 6, 811-13 (1949). Investigation of hardness of sintered Ni-plates for battery elements. Contains a description of a microhardness tester used on Ni plates

sintered for various times. Relation between hardness numbers of Ni compacts sintered various times and angle of conical indenter is shown.

(2347) Fractographic Examination of Tungsten. C. A. Zapffe and F. K. Landgraf, *Trans. Am. Soc. Metals, 41,* 396-418 (1949). Typical fractographs of cleavage facets of cast W, and pure W made by powders.

(2348) Tentative Method for Acceptance Tests on Structural Parts Made from Metal Powders. Metal Powder Association. M. P. A. Standard 8-50T, 1950, 4 pp. Specifies methods by which structural parts may be tested, as a basis for acceptance. The details of the test and range of values to be obtained are to be agreed upon by the user and producer of the part. Chemical composition, density, porosity, manufacture, dimensions and tolerances, mechanical properties, hardness, sampling and certificate of test are discussed.

(2349) Tension Test Specimens for Pressed and Sintered Metal Powders. Metal Powder Association. M.P.A. Standard 10-50T, 1950, 3 pp. Describes a flat tension specimen and a round machined tension specimen to be used in determinations of the tensile characteristics of pressed and sintered metal powders used in powder metallurgy. Diagrams of these specimens are shown, and the apparatus, lubrication of the die, compacting, sintering and testing are discussed.

IV. Powder Metallurgy Products; Their Composition, Properties, and Manufacture

1. REFRACTORY METALS AND ALLOYS

(2350) Metals of The Tungsten and Tantalum Groups. C. W. Balke, *Ind. Eng. Chem., Ind. Ed., 21,* 1002-7 (1929). Application of powder metallurgy of W, Mo, Ta, Co.

(2351) J. W. Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry.* Vol. XI, Longmans, Green, London, 1931. Chapters 59-62 treat the metals tellurium, chromium, molybdenum, and tungsten.

(2352) W. Espe and M. Knoll, *Werkstoffkunde der Hochvakuumtechnik,* Springer, Berlin, 1936. The refractory metals tungsten, molybdenum, tantalum and columbium are extensively surveyed for high vacuum applications.

(2353) Wetting of Hot Metal Filaments by Molten Metals. M. A. Countryman, *Proc. Iowa Acad. Sci., 44,* 147-8 (1937). Al, Ag, Cu, Au, Ni, Cr, Pt evaporated on filaments of Ni, Pt, Mo, Ta, W.

(2354) Powder Metallurgy: Tungsten and Other Refractory Metals. S. L. Hoyt, *Metal Progress, 32,* 749-54 (1937). A review; production and uses of W, Ta, Mo and Cb.

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A. Tungsten and molybdenum

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(2433) New Methods of Working in Manufacture of Filaments. B. Duschnitz, *Helios Fach Z., 34,* 473-78 (1929). Patents claiming addition of hafnia to tungsten wires for stiffening; coating with Ta carbides or nitrides are reviewed.

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(2472) The Growth of Tungsten Crystals, and the Effect of Direct Current. R. W. Schmidt, *Z. Physik, 120,* 69-70 (1942). Filaments, during use, show recrystallization in certain regular intervals, whose distance increases with the increase in temperature. Micropictures.

(2473) Molybdenum. J. W. Vanderwilt, *Steel, 111,* No. 19, 86, 125 (1942). A summary of properties, uses, methods of detection and analysis.

(2474) Tungsten and Its Ores. J. L. F. Vogel, *Chem. Trade J., 111,* 141-142 (1942). Reduction methods for the metal to be used in carbides and filaments of highest purity. W can be incorporated in molten steel by reducing it in an electrical furnace or by aluminothermic method.

(2475) Manufacture of Tungsten Metal. P. E. Wretblad, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 38, pp. 420-435. Powder production, pressing, sintering, fabrication of wire, additives to filaments discussed.

(2476) Tungsten Filaments by Powder Metallurgy. *Metals & Alloys, 17,* No. 5, 1098 (1943). Applications of powder metallurgy include the making of filaments by Westinghouse Electric & Mfg. Co.

(2477) Tungsten. E. J. Clement, *Mill & Factory, 35,* 120, 121, 278, 282, 286, 290, 292, 296 (1944). Production of grey tungsten powder from ores. Alloys, filaments, carbides discussed.

(2478) Recrystallization Texture of Coiled Tungsten Filaments. R. W. Schmidt, *Z. Metallkunde, 36,* No. 1, 23-24 (1944). Differences in direction of texture of recrystallization in drawn wires and in mandrel and spring wires.

(2479) Tungsten. J. F. Junior and P. DeLima, *Sao Paulo Inst. Geograph. e Geol. Bol., 31,* 962-966 (1945). A monograph with sections on mineralogy, ore dressing process, metallurgy, properties, uses; references.

(2480) New Process for Producing Tungsten Shapes. *Materials & Methods, 23,* No. 6, 1708 (1946). New method developed by Kennametal Inc., Latrobe, Pa., for the production of large crucibles, etc., of pure W.

(2481) Production of Molybdenum and Tungsten for Radio Valves and Lamps. J. S. Harrison, H. Williams and R. W. Rees, B.I.O.S. Final Rept. No. 684, 1946, 29 pp.; *Met. Powd. Rept., 1,* No. 3, 43 (1946). This report gives full details of starting material, the type of plant employed at the various stages, and the technique laid down for the treatment of materials and operation of the plant.

(2482) Production of Molybdenum and Tungsten for Radio Valves and Electric Lamps at Metallwerk Plansee. J. S. Harrison, H. Williams and R. W. Rees, U. S. Dept. Comm. PB. 48445/1946, 32 pp.; *Bibl. Scient. & Ind. Rept., 3,* No. 13, 955 (1946). The MoO_3 was reduced with H in two stages; in first stage H was burned to waste, but purified and recycled in second stage. *Cf:* B.I.O.S. Final Rept. No. 684 (1946).

(2483) Tungsten and Molybdenum Metallurgy of Japan. Gen. Headquarters Supreme Commander Rept. 61, 1946, 30 pp. Review.

(2484) Effect of Working on Physical Properties of Molybdenum. J. W. Marden and D. M. Wroughton, *Trans. Electrochem. Soc., 89,* 217-228 (1946). Effect of working on hardness, tensile strength and elongation of Mo is presented in form of graphs.

(2485) War Job of Tungsten and Molybdenum Products. M. H. McClement, *Steel, 118,* No. 9, 141 (1946). Brief note on role of these metals during World War II.

(2486) Tungsten and Molybdenum Wire. D. E. Tesen, F.I.A.T. Final Rept. No. 413, 1946, 16 pp.; *Met. Powd. Rept., 1,* No. 2, 21 (1946). Description of wire production at the German plants of Gebr. Borchers, Osram, Metallwerk Plansee, etc.

(2487) Tungsten and Molybdenum Wire. D. E. Tesen, U.S. Dept. Comm. PB. 18785, 1946, 10 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 20, 1183 (1946). German W and Mo industry is investigated, description of the plants. No change in methods of extraction of purification of oxides and metals was found.

(2488) Ductile Melted Molybdenum. *Metal Ind. (London), 70,* No. 6, 106-13 (1947). Economics and limitations of powder metallurgy methods of producing ductile Mo discussed. New vacuum arc fusion process described.

(2489) Molybdenum in "Chunks". *Steel, 120,* No. 13, 90 (1947). Westinghouse was successful in producing molybdenum in chunks of large size.

(2490) Properties and Application of Molybdenum. J. Gelok, *Materials & Methods, 26,* No. 3, 86-89 (1947). Pressing, properties, working, characteristics, uses of the powder; powder production methods.

(2491) Molybdenum – A Practical Structural Material. J. Gelok, *Westinghouse Eng., 7,* No. 5, 156-59 (1947). Production of ingots; properties, applications.

(2492) Manufacture of Tungsten Rod in Australia. J. N. Greenwood, *Chem. Eng. & Mining Rev., 39,* No. 10, 367 (1947). Wolframite concentrate from Storey Creek, Tasmania, contains 73.1% WO_3 from which W powder is produced. A plant is erected in the Metallurgical School of University of Melbourne, designed to produce 1500 lbs. per year of tungsten rod and wire.

(2493) Manufacture of Tungsten Rod and Wire in Australia. J. N. Greenwood and R. H. Myers, *Nature, 160,* No. 4072, 675 (1947). Refers to experiments to determine the relationship between annealing temperature and hardness of Ta after cold working.

(2494) K. C. Li and C. Yu Wang, *Tungsten.* Reinhold, New York, 1947, 430 pp. Geology of tungsten. Ore dressing. Metallurgy. Chemistry. Analysis of tungsten. Industrial applications. Economics of tungsten.

(2495) Dressing of Tungsten Minerals. F. B. Michell, *Mine & Quarry Engr., 13,* 204-10 (1947); *C. A., 41,* No. 21, 6850 (1947). Survey of general practices resulting in the pure metal as end product.

(2496) Production of Tungsten Wire and Processing of Scheelite. H. R. Williams, B.I.O.S. Final Rept. No. 962, 1947. A detailed description of tungsten wire

production from crude tungstic acid hydrate (via ammonium paratungstate) and scheelite (via calcium tungstate). Contains much data on doping and an elutriation apparatus.

(2497) High-Temperature Ceramic Coatings for Molybdenum. *Chem. Eng. News, 26,* No. 45, 3362-63 (1948). Zirconia coatings developed by Natl. Bur. of Standards have afforded protection at 1650° C. (3000° F.) for 45 min.

(2498) High-Temperature Ceramic Coatings for Molybdenum. *Natl. Bur. Standards, Tech. News Bull., 31,* 125-6 (1948). Protection afforded Mo by a zirconium oxide ceramic coating is demonstrated by specimens exposed to high-temperature flame tests.

(2499) Thin Oxide Films on Tungsten. E. A. Gulbransen and W. S. Wysong, *Trans. Am. Inst. Mining Met. Engrs., 175,* 611-27 (1948). Behavior of W and its surface oxides in atmosphere or vacuum is question of considerable technical importance.

(2500) Thin Films on Molybdenum. E. A. Gulbransen and W. S. Wysong, *Trans. Am. Inst. Mining Met. Engrs., 175,* 628-647 (1948). Use of Mo in oxidizing atmosphere at elevated temperatures has been limited because of unprotective nature of its oxide films.

(2501) Tungsten; Metallurgy, Properties, Applications. R. Kieffer and F. Benesovsky, *Elektrotechnik u. Maschinenbau, 65,* No. 1/2, 17-20 (1948). A detailed review. Metallurgy, properties and use of tungsten, development of metallurgy of sintered W, raw materials, Coolidge method of manufacture of ductile W, and sintered W alloys are discussed.

(2502) Molybdenum: Metallurgy, Properties, Applications. R. Kieffer and F. Benesovsky, *Elektrotech. u. Maschinenbau, 65,* No. 9/10, 140-46 (1948). A detailed review is given of the development of molybdenum metallurgy and industrial uses of the metal.

(2503) Electrical High-Temperature Furnaces with Molybdenum Resistors. R. Kieffer and B. Natter, *Radex Rundschau,* No. 3/4, 49-56 (1948). Characteristics of Mo, and its use in electric furnace constructions is discussed.

(2504) High-Temperature Ceramic Coatings Developed for Molybdenum. *Steel, 124,* No. 4, 59,82 (1949). Investigations by National Bureau of Standards show that molybdenum must be protected in order to be used at high temperature in oxygen-bearing atmospheres; ceramic coatings are applied in form of water suspensions. Tests indicate retardation of oxidation. Immediate application of ceramic coatings is protection of molybdenum Pitot tubes, for recording the pressure in the blast of ram-jet engines.

(2505) Tungsten Metallurgy. J. Challansonnet, *Métaux & corrosion, 24,* No. 287-288, 163-76 (1949). Historical development of the metal tungsten; W-minerals; fabrication of ductile tungsten; physical and chemical properties; preparation of WO_3 and of W-powders; microstructure; x-ray patterns; recrystallization; industrial applications, W-carbides, Fe-W alloys, stellite, etc.; tables, diagrams, photographs.

(2506) Molybdenum. Production, Properties and Applications. G. L. Miller, *Metal Ind. (London), 75,* 411-13, 439-41 (1949). Describes the Westinghouse process of sintering Mo pressings in moist H; and the Climax Molybdenum process in which a bar of pressed powder is melted in an electric arc and cast in water-cooled copper molds.

(2507) Welding of Pure Molybdenum. H. J. Nichols, K. B. Young and M. J. Nolan, *Welding J., 28,* No. 5, 236-s (1949). High purity molybdenum is used in the investigation.

(2508) Tungsten-Molybdenum Thermocouples. R. D. Potter and N. J. Grant, *Iron Age, 163,* No. 13, 65-69 (1949). Metallurgical factors to be observed in order to attain optimum results from the metal components are discussed. The procedure for calibrating is outlined.

(2509) Tungsten. T. F. Smeaton, *Inst. of Mining and Metallurgy, Symposium on Refining of Non-Ferrous Metals,* No. 18, 1949, 20 pp. Its preparation for use in electronics and carbide products.

(2510) The Tungsten-Iridium Thermocouple for Very High Temperatures. W. C. Troy and G. Steven, *Trans. Am. Soc. Metals, Preprint No. 19,* 19 pp. (1949). Calibrations were made for thermocouples representing combinations of W, Mo, Pt, Ta, Rh, Ir and alloys of these metals for temperatures of 2910 to 3630° F. In neutral atmosphere or vacuum, the W-Ir thermocouple gave best results because of the high emf, an almost linear calibration curve between 1830 and 3810° F., negligible room-temperature emf, and thermoelectric stability.

(2511) Tungsten: To Save or Not to Save? R. W. Tuthill, *Welding Eng., 34,* No. 3, 42-45 (1949). Tungsten consumption and cost to user; effect of deposited W on weld strength is still unknown; incorrect current density and oxidation of electrode used in inert arc welding are serious causes for high W loss; tests run on a.c. argon aluminum show losses; specific example assumed to illustrate cost and consumption of W; problem of protecting W electrode.

(2512) Fractographic Examination of Tungsten. C. A. Zapffe and F. K. Landgraf, *Trans. Am. Soc. Metals, 41,* 396-418 (1949). The study serves to call attention to several informative and characteristic structures of W.

B. Tantalum and columbium

(2513) Tantalum and Its Compounds. J. J. Berzelius, *Poggendorffs Ann., 4,* 10-21 (1825). Tantalum powder was produced by the reduction of K_2TaF_7 with potassium, and the powder was worked into an ingot.

(2514) Tantalum Metal. H. Rose, *Poggendorffs Ann., 99,* 69-81 (1856). Tantalum powder was produced by reduction of Na_2TaF_7 with sodium, and attempts were made to produce the compact metal.

(2515) Tantalum Metal. H. Rose, *Poggendorffs Ann., 100,* 146-65 (1857). Tantalum powder was produced by reduction of $TaCl_5$ with sodium in a steel bomb, and attempts were made to convert the powder into compact metal.

(2516) Tantalum - Its Production and Properties. W. v. Bolton, *Z. Elektrochem., 11,* No. 2, 45-51 (1905). The use of tantalum for the production of filaments is described. Ductile tantalum is produced by the dissociation of Ta_2O_4.

(2517) Columbium – Its Preparation and Properties. W. v. Bolton, *Z. Elektrochem., 13,* 145-49 (1907). Production of pure columbium. Chemical and physical properties.

(2518) Investigations of Metallic Vanadium, Columbium, and Tantalum. W. Muthmann, L. Weiss and R. Riedelbauch, *Ann. Phys. Leipzig, 355,* 58-136 (1907); *Chem. Zentr. II,* 1151 (1907). Tantalum powder was obtained by reduction of Ta_2O_5 with cerium ("Mischmetall"); the compact metal was attempted from the metal powder.

(2519) Ductile Tantalum. C. W. Balke, *Ind. Eng. Chem., Ind. Ed., 15,* 560-562 (1923). Preparation of Ta compounds; properties; uses. A Ta electrode could be used for the deposition of Zn directly, which does not alloy with Ta metal. Aqua regia does not attack the electrode. By using two Ta electrodes in a single cell the alternating current is converted to D.C.

(2520) Thermal Expansion of Tantalum. P. Hidnert, *J. Research Natl. Bur. Standards, 2,* No. 62, 887-896 (1929). Use of Ta, materials investigated, apparatus, results; curves and equations given.

(2521) Thermal Expansion of Columbium. P. Hidnert and H. S. Krider, *J. Research Natl. Bur. Standards, 11,* No. 590, 279-284 (1933). Material investigated - apparatus, curves and equations.

(2522) The Development of Sending Tubes. S. Ganswindt and K. Matthies, *Z. tech. Physik, 15,* 26-27 (1934). The use of columbium for incandescent cathodes is described.

(2523) Columbium and Tantalum. C. W. Balke, *Ind. Eng. Chem., Ind. Ed., 27,* 1166-69 (1935). Treatment of ore; preparation of the metals; properties and applications of Ta and Cb, and their carbides.

(2524) Recent Development in Tantalum and Columbium. C. W. Balke, *Ind. Eng. Chem., Ind. Ed., 30,* 251-254 (1938). Production by powder metallurgy. Attention must be given to the physical characteristics of the powder; variation of the heating process in relation to the grain size; hydrochloric acid gas absorption unit; applications described.

(2525) Tantalum and Columbium – New Applications. C. W. Balke, *Metal Ind. (London), 52,* 425-27 (1938). Metallurgy; grain size; finished sheets; conversion of scrap. Hard carbide compositions.

(2526) Ductile Tantalum and Columbium. C. W. Balke, *Trans. Am. Inst. Mining Met. Engrs., 128,* 67-75 (1938). Bars of ductile Ta and Cb by powder metallurgy processing methods described.

(2527) Powder Metallurgy Permits Working of Refractory Metals. T. F. Mika, *Metals Rev., 12,* No. 9, 6 (1939). Review of lecture by C. W. Balke on the refractory metals of Ta and Cb; carbides also discussed.

(2528) Powder Metallurgy. C. C. Balke, *Iron Age, 147,* No. 16, 23-27 (1941). Discussion includes reference to the metallurgy and sintering phenomena of tantalum.

(2529) Production of Metal Powders. C. W. Balke, *Metal. Ind. (London), 58,* 502-05 (1941). Production of solid tantalum from its powder is described.

(2530) Review of Literature on Chemistry and Metallurgy of Tantalum and Columbium. R. H. Myers, *Proc. Australasian Inst. Mining Met., 129,* 55-79 (1943). Preparation, properties, uses of the metals and their carbides, nitrides, hydrides, borides. 52 references.

(2531) Pure Columbium. C. W. Balke, *Trans. Electrochem. Soc., 85,* 89-95 (1944). Separation of Cb from Ta and other constituents by fractional crystallization of complex salts and fractionation of metal chlorides at elevated temperatures produces a very pure columbium oxide. Co oxide and Cb carbide are mixed and heated in vacuo, to produce the metal.

(2532) Tantalum in Medicine and Surgery. M. Z. Gross, *Hygeia, 22,* 438-40 (1944). Tantalum is used to unite fractured bones and to replace lost skull tissue. Repaired nerves are protected by tantalum foils.

(2533) Minor Metals. A. R. Powell, *Metal Ind. (London), 66,* 406-10 (1945). Technical applications of tantalum and columbium, as well as titanium, and zirconium are discussed.

(2534) Preparation and Consolidation of Tantalum Powder. R. H. Myers, *Proc. Australasian Inst. Mining Met.,* (New Series), *144,* 15-44 (1946). Following the preparation of Ta-oxide and Ta-carbide described in *Proc. 129* (1943) an investigation of production of Ta-powder was planned; electrolytic methods, consolidation of powder, sintering of pressed bars, swaging and wire drawing.

(2535) Occurrence, Extraction and Use of Columbium and Tantalum. G. Oldham, *Mining J., 226,* No. 1, 29-30 (1946). Ta and Cb are used for electrodes for thermionic devices and as getters; their carbides are extremely resistant to chemical action.

(2536) Production of Tantalum in Japan. E. J. Drake, B.I.O.S., J.A.P./P.R./847 1947, 7 pp.; *Met. Powd. Rept., 2,* No. 4, 52 (1947). Process of making tantalum powder from tantalite via double fluorides.

(2537) Annealing Temperature and Hardness of Tantalum. J. W. Greenwood and R. H. Myers, *Nature, 160,* 675 (1947); *Met. Powder Rept., 2,* No. 4, 53 (1947). Cold-worked Ta is slightly softened by annealing to 1100° C. (2010° F.), but hardness and brittleness rise sharply with annealing temperature up to 1800° C. (3270° F.) after which a reduction takes place up to 2400° C. (4350° F.). Slow cooling from the latter temperature gives a soft product, but rapid cooling at 7° C./min. (12.6° F./min.) again produces hardness and brittleness.

(2538) Uses for Tantalum and Columbium. T. A. Hood, *Australia Dept. Munitions, Inform. Circular No. 11,* 1947, 18 pp. Detailed description of commercial applications.

(2539) Tantalum as Engineering Material. K. Rose, *Materials & Methods, 26,* No. 4, 94-98 (1947). Annealed Ta is malleable and ductile, can be stamped, formed or deep drawn.

(2540) Tantalum in Electronics. L. F. Yntema and R. W. Yancey, *Trans. Electrochem. Soc., 91,* 485-89 (1947); *Materials & Methods, 26,* No. 3, 119-120 (1947). High melting point of Ta and its reactivity at high temperatures dictate the powder technics involved. Powder pressed into billets and sintered in high vacuum.

(2541) Tantalum Heat Exchanger. *Chem. Process, 11,* No. 3, 8 (1948). Tantalum heat exchanger built by Fansteel Metallurgical Corp., North Chicago, Ill., resists action of chlorinated brine.

(2542) Australian Investigations on Tantalum. *Iron & Coal Trades Rev., 156,* No. 4181, 898 (1948). Refers to three papers published by Australian Institute of Mining and Metallurgy.

(2543) Story of Tantalum. C. W. Balke, *Chemistry & Industry (London),* No. 6, 83-85 (1948). Author outlines development of tantalum and columbium manufacture with which he has been associated since 1916.

(2544) Sintering of Electrolytic Tantalum Powder. R. H. Myers, *Metallurgia, 38,* No. 228, 307-10 (1948). Procedure and properties of the finished metal are given.

(2545) Tantalum in Everyday Use. M. Schofield, *Discovery, 8,* 244-45 (1948). Increasing use for filaments in electronic devices with d.c. heating. Except for a tendency to oxidize at 150° C. (300° F.) it is the supreme noble metal, used also in chemical engineering.

(2546) Tantalum. G. L. Miller, *Ind. Chemist, 25,* 388-90 (1949). A useful review of production methods and applications.

C. High-melting precious metals

(2547) Allessio Piemontese (Pseudonym), *Secreti.* 1555. (English Translation, London, 1559-1560). A description is given of the production of gold powders. A gold amalgam was made from hot gold and mercury. After straining to remove excess Hg, the amalgam was ground with sulfur. The mixture was then heated to volatilize both S and Hg.

(2548) The White Gold, or the Seventh Metal Called in Spain "Platina del Pinto." H. T. Scheffer, *Handlingar, K. Svenska Vetenskaps Academiens (Stockholm), 13,* 269-275 (1752). It was noted that when platinum was heated with arsenic it showed signs of superficial melting.

(2549) Experimental Examination of a White Metallic Substance Said to Be Found in the Gold Mines of Spanish West Indies. W. Lewis, *Phil. Trans. Roy. Soc., 48,* 638-689 (1755). It was found that an alloy of lead and platinum, when thoroughly oxidized at a high temperature, left a spongy mass of platinum that could be forged.

(2550) W. Lewis, *Philosophical Commerce of Arts.* London, 1763, 646 pp. Description of a portable furnace for making experiments is given. Discussion of the color of gold, density, ductility, gold-beating, wire-drawing, effects of heating, alloys of gold, assaying, and the action of acids on gold, compacted from the powdered metal.

(2551) Easy Method to Prepare Containers from Platinum. F. C. Achard, *Preuss. Akadem. Wissenschaft, Berlin, Mem., 10,* 89-97 (1779). Method involves forming a lower-melting pre-alloy, *e. g.*, a platinum-arsenic eutectic, and volatilizing the alloying constituents.

(2552) About Arsenic and Its Combination with Different Bodies. F. C. Achard, *Preuss. Akadem. Wissenschaft, Berlin, Mem., 12,* 103-119 (1781). A sponge of platinum metal that could be hot-hammered to a compact mass was produced by

uniting platinum with arsenic to form a readily fusible alloy and then volatilizing the arsenic by prolonged heating.

(2553) Treatment of Platinum and Its Use in the Arts. A. Rochon, *J. de Phys. Chém. Arts, 47,* 3-15 (1798). An improvement of the arsenic process for the production of malleable platinum is given. It was found that fragments of scrap platinum could be welded together when enclosed in sheet, and malleable platinum was produced by so uniting flux-purified grains of native platinum.

(2554) Observations on Platina. A. Rochon, *Phil. Mag., 2,* 19, 170-180 (1798). Forged platinum from powder; cast platinum.

(2555) Process for Rendering Platina Malleable. R. Knight, *Phil. Mag., 6,* 1-3 (1800). First attempts to win ductile platinum from platinum black (sponge powder) are reported.

(2556) A New Method to Forge Platinum. A. von Mussin-Puschkin, *Allgem. J. Chem. (Scherer), 4,* 411 (1800). Platinum sponge was produced by reacting mercury with Pt to form a fusible alloy, which was then heated to volatilize the Hg.

(2557) Malleable Platinum. A. Tilloch, *Phil. Mag., 21,* 175-188 (1805). A new process of rendering platina malleable.

(2558) Malleable Platinum. A. F. Gehlen, *Beitr. zur Chemie und Physik, 7,* 309, 514 (1813). According to a letter by Leithner quoted by the author, thin malleable sheets of platinum were produced by drying out successive layers of the metallic powder mixed with turpentine, and then firing the resulting films at a very high temperature without the application of pressure. Mention is made of Wollaston platinum, the author considering it superior to that of Jannetty.

(2559) Malleable Platinum. C. Ridolfi, *Quart. J. Sci. Lit. Arts, Roy. Inst. Great Britain, 1,* 259-260 (1816). Translation from *Giornale di Scienza ed Arti (Florence),* 1816. It was proposed that malleable platinum for chemical vessels be produced by heating an alloy of platinum and lead or sulfur to drive off the volatile constituent.

(2560) Process for Producing Pure Metals. M. Baruel, *Quart. J. Sci. Lit. Arts, 12,* 246 (1822). Processes for pure platinum, palladium, rhodium, iridium and osmium from powders are described.

(2561) A Method of Rendering Platina Malleable. W. H. Wollaston, *Phil. Trans. Roy. Soc., 119,* 1-8 (1829). Historical interest. Pt ground to a powder, compressed in a crude press, heated in a charcoal fire and finally in a wind furnace and then hot-forged.

(2562) An Account of the Russian Method of Rendering Platinum Malleable. W. Marshall, *Phil. Mag., 11,* 321-330 (1832). The ore is dissolved in aqua regia, the solution contains muriate of Pt and shows a tendency to crystallization. The resulting powder is compacted, heated and worked.

(2563) Processing of Platinum in Russia. P. Sobolewskoy, *Ann. Phys. u. Chem., 109,* 99-109 (1834). Sifted platinum powder was pressed in a cast iron cylinder with a screw-actuated steel punch. The compacts were annealed at a high temperature which made them malleable.

(2564) H. E. Roscoe and C. Schorlemmer, *A Treatise on Chemistry.* London, 1877-84. An account of the process for making malleable platinum which was the forerunner of the Wollaston process is given on p. 388.

(2565) On the Density of Rhodium. T. K. Rose, *J. Inst. Metals, 33,* 109-11 (1925). Sample A: forged up from sponge; sample B: melted in oxy-hydrogen flame; both had a density of 12.472.

(2566) The Platinum Metals. S. C. Ogburn, *J. Chem. Education, 5,* 1371-84 (1928). The powder metallurgy of platinum at the beginning of the nineteenth century is described.

(2567) Platinum. D. McDonald, *J. Soc. Chem. Ind., 50,* 1031-41 (1931); *Chemistry & Industry, 9,* 1031-41 (1931). Occurence; purification and (powder) metallurgy; properties and uses, production and marketing.

(2568) Fabrication of Platinum Metals. C. S. Sivil, *Trans. Am. Inst. Mining Met. Engrs., 93,* 246-60 (1931). Forging and rolling technique is given for platinum. Topics discussed are ingot molds, sintering, arc melting, induction melting, atomic hydrogen and flame welding, and working.

(2569) Metals of the Platinum Group. Ores, Recovery, Fabrication and Uses, and Properties. R. H. Atkinson and A. R. Raper, *J. Inst. Metals, 59,* 179-207 (1936). Powder metallurgy method is compared with fusion method, and favored where highest purity and freedom from gas contamination is desired.

(2570) The Metallurgy and Technology of Gold and Platinum among the Pre-Columbian Indians. P. Bergsøe, *Ingeniörsvidenskab. Skrifter, A No. 44,* Kopenhagen, 1937. Platinum is cemented by metals of lower melting point which tend to wet the platinum and coalesce the grains.

(2571) Pressing of Platinum Powder. O. E. Zvyagintsev, *Sbornik Nauch. Trudos, Moskav Inst. Tsvet. Metallov Zolota, 9,* 426-430 (1940) (in Russian). Experiments carried out on pressing of Pt powder and subsequent annealing at 1000° C. (1830° F.) for 1½ hrs. Results show that Pt obtained in this way has a structure, density and toughness superior to that of Pt obtained from molten metal.

(2572) Some Remarks on the Wollaston Method of Producing Compact Platinum from Sponge Powder. J. S. Streicher, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 2, pp. 16-17. An appendix to paper on early development of powder metallurgy by C. S. Smith. Description of 9 steps applied by Wollaston in manufacture of compact Pt metal.

(2573) Platinum-Iridium Alloys. O. Zvyagintsev, A. Rakhstadt and M. Vladimikova, *J. Applied Chem. (U.S.S.R.), 17,* 20-30 (1944). Study of process of diffusion was made on Pt-Ir alloys containing 10, 25, 35, and 50% Ir; alloys were produced by powder metallurgy.

(2574) Platinum-Iridium Alloys by Powder Metallurgy. O. Zvyagintsev, A. Rakhstadt and M. Vladimikova, *Metallurgia, 34,* No. 202, 195-198 (1946); *Met. Powd. Rept., 1,* No. 2, 24 (1946). Condensed translation of article of item 2573.

(2575) Platinum Metals. C. A. H. Jahn, *Metal Ind. (London), 72,* 183-185 (1948). The survey includes methods of producing Pt, Pd, Ir, Rh, Ru, Os, their properties and their applications.

(2576) Pure Platinum, of High Recrystallization Temperature, Produced by Powder Metallurgy. A. B. Middleton, L. B. Pfeil and E. C. Rhodes, *J. Inst. Metals , 75,* Pt. 7, 595-608 (1949). By sintering and hot working a fine powder compact of pure platinum, at temperature considerably below its melting point, followed by severe cold drawing to wire, the fibrous structure of the resulting wire is made to persist when heated at temperatures well above recrystallization temperature of wire produced from melted, cast, and similarly worked pure platinum.

D. Rare metals

(2577) Thorium. W. v. Bolton, *Z. Elektrochem., 14,* No. 47, 768-70 (1908). The properties of the metal are given, as "muriaticum-thorium" is discussed.

(2578) Thorium. H. v. Wartenberg, *Z. Elektrochem., 15,* 870-72 (1909). The production and a thermo-chemical investigation of thorium are described; thorium sulfide is also referred to.

(2579) Preparation of Thorium, Uranium, Zirconium and Titanium. D. Lely and L. Hamburger, *Z. anorg. allgem. Chem., 87,* 209-210 (1914). Same method used for all the metals. Chloride was reduced by Na in steel bomb and metal precipitated, then compacted, and made the resistor in an electric vacuum furnace and heated until fused together.

(2580) Metallurgy of Titanium. R. J. Anderson, *J. Franklin Inst., 184,* 469-508, 637-50, 885-900 (1917). A survey of the production and uses of titanium.

(2581) Yttrium. J. F. G. Hicks, *J. Am. Chem. Soc., 40,* 1619-20 (1919). Preparation and properties of yttrium or rather of "mixed metal" containing yttrium are described.

(2582) Investigation of Zirconium with Special Reference to the Metal and Its Oxides. J. W. Marden and M. N. Rich, *Bur. of Mines, Bull. 186,* 1921, 152 pp. Treatment of the ore; purification; uses of Zr; analytical determination; bibliography.

(2583) Titanium and Its Alloys. R. J. Anderson, *Raw Material, 5,* 440-44 (1922). The production of pure Ti by the usual metallurgical reduction processes is difficult, owing of the high melting point of metal, and its strong affinity for N, O, and C.

(2584) Metallic Titanium, Zirconium, Hafnium, and Thorium. *Metallurgist* (Suppl. to *Engineer*), *1,* 175 (1925). The methods of producing the metals in the pure state are discussed.

(2585) Zirconium. J. H. De Boer and J. D. Fast, *Z. anorg. allgem. Chem., 153,* 1-8 (1926). A thermal dissociation of the iodide is described in a survey of the various methods for producing the metal. The ductile metal can be produced in this way.

(2586) Metallurgy and Uses of V and Ti. G. M. Dyson, *Chem. Age (London), 14,* Metallurgical Section, May, 33-5 (1926). Distribution, preparation, properties and uses are discussed.

(2587) Thorium. J. W. Marden and H. C. Rentschler, *Ind. Eng. Chem., Ind. Ed., 19,* 97-103 (1927). The preparation of thorium powder by reduction of the oxide with calcium and calcium chloride and the production of formed sintered bodies from the powder so prepared is described.

(2588) Vanadium. J. W. Marden and M. N. Rich, *Ind. Eng. Chem., Ind. Ed., 19,* 786-788 (1927). Vanadium pentoxide is reduced with calcium and calcium chloride. The resulting granules are sufficiently ductile to be cold worked, but are too coarse to be compacted into solid shapes.

(2589) Zirconium. J. H. De Boer, *Foote Prints, 3,* No. 2, 3-24 (1930). Reducing Zr compounds to metal; preparation of massive ductile Zr; properties, uses.

(2590) Preparation of Pure Zirconium. J. H. De Boer and J. D. Fast, *Z. anorg. allgem. Chem., 187,* 177-192 (1930). Various methods of preparing this rare metal are discussed. A thermal dissociation of the iodide is described in detail, and the properties of the resulting compact metal are given.

(2591) Preparation of Pure Hafnium. J. H. De Boer and J. D. Fast, *Z. anorg. allgem. Chem., 187,* 193-208 (1930). Pure hafnium shows a very high ductility and can easily be cold-worked. Complicated methods for its preparation are described, and the method of thermal dissociation of halides is especially referred to.

(2592) Physical and Chemical Properties of Rhenium. C. Agte, H. Alterthum, K. Becker, G. Heyne and K. Moers, *Z. anorg. allgem. Chem., 196,* No. 2, 129-59 (1931). Various properties are discussed. Massive metal is produced by reduction of decomposed gaseous chlorides and precipitation on a hot tungsten wire.

(2593) Physical Properties of Rhenium. C. Agte, H. Alterthum, K. Becker, G. Heyne and K. Moers, *Naturwissenschaften, 19,* No. 5, 108-109 (1931). Structure of crystals; their thermal, mechanical and electrical properties.

(2594) Titanium and Zirconium. F. H. Driggs and J. W. Marden, *Mineral Ind., 39,* 602-11 (1931). An electrode containing 98% W, 1.5% Ti, 0.5% Cr is used as a source of ultraviolet radiation. Zr is used in the preparation of flashlight powder. Zr with 2% Al is used for thermionic cathodes.

(2595) Metallurgy of Some of the Rarer Metals. C. J. Smithells, *Metal Ind. (London), 38,* 336 (1931). Treatment of Zr, Ta, Mo, Cb is described.

(2596) Preparation of Some Rare Metals. A. E. Van Arkel, *Rev. Univ. Mines, 8,* No. 1, 37-41 (1932). Preparation of massive ductile Zr, Ti, Th by thermal dissociation of their iodides in vacuo on a W filament in described. Similar methods may be used to prepare V in an evacuated quartz tube. Boron is prepared in form of a hard and brittle rod by reduction of the bromide with Hg vapor.

(2597) Production of Seamless Tubes from Materials of High Melting Point. J. A. M. Van Liempt, *Metallwirtschaft, 11,* 357-59 (1932). Tubing is produced by the deposition of Ti on a core, followed by chemical solution of the core.

(2598) The Discovery of the Elements – XI. M. E. Weeks, *J. Chem. Education, 9,* 1231-43 (1932). Titanium was isolated with the aid of potassium and sodium.

(2599) Zirconium. G. H. Chambers, *Metals & Alloys, 4,* No. 12, 199-201 (1933); *Foote Prints, 6,* 20-28 (1933). Chemical and physical properties, production, market price and uses are discussed; ductile Zr and zirconium carbide tools are also surveyed.

(2600) I. Noddack and W. Noddack, *Das Rhenium.* Voss, Leipzig, 1933. The metallurgy (including powder metallurgy) of the metal rhenium is treated.

(2601) Diffusion of Titanium and Dissociation of Titanium Compounds. I. S. Gaev, *Metallurg., 9,* No. 10, 19-33 (1934). An early carefully conducted and thorough study of diffusion of titanium in iron is reported. Data on iron-titanium metal powders, and on dissociation of titanium compounds are given.

(2602) Titanium in Metallurgy. M. A. Hunter and A. Jones, *Trans. Electrochem. Soc., 66,* 21-32 (1934). The alloys of Ti, their production and uses are described.

(2603) Metallurgy of Ti by the Haglund Method. J. Kleffner, *Metall u. Erz, 31,* No. 14, 307-20 (1934). A report on the production of Ti by dissociation of Ti sulfide; the phenomenon of the Haglund method is investigated.

(2604) Ductile Chromium. W. Kroll, *Z. anorg. allgem. Chem., 226,* 23-32 (1935). Pure Cr by reduction of anhydrous chloride or of pure oxide (CrO_3). Pressure reduction in tank. Best salt for reduction of CrO_3: $BaCl_2/CaCl_2$ melt. Metal produced by compaction and sintering in argon at 100 mm. Hg, at 1600-1700° C. (2900-3100° F.), then hot-rolling at 1200° C. (2200° F.) under $BaCl_2$ cover.

(2605) Workable Raw Materials, Vanadium, Thorium and Uranium. W. Kroll, *Z. Metallkunde, 28,* 30-33 (1936). Production of their powders from their oxides, then compaction, sintering and metal working.

(2606) Crack-Free Forming of Zirconium and Titanium . J. D. Fast, *Foote Prints, 10,* 1-24 (1937). Tensile strength and ductility tests on wrought metals. Production of zirconium and titanium from their iodides.

(2607) Workable Titanium and Zirconium. W. Kroll, *Z. anorg. allgem. Chem., 234,* 42-50 (1937). The chemical and the metallurgical conditions for the reaction of Ti or Zr from their halogen or oxygen compounds. Apparatus for the reduction of the oxides with Ca; the produced metal can be worked when hot, but it is brittle when cold.

(2608) Crack-Free Forming of Zirconium and Titanium. J. D. Fast, *Metallwirtschaft, 17,* 459-62 (1938). Production of zirconium and titanium from their iodides is described, and results of tensile strength and ductility tests are reported.

(2609) Zirconium and Its Compounds. J. D. Fast, *Philips Tech. Rev., 3,* 345-52 (1938). Zirconium is often used in discharge tubes where its high melting point and small value of secondary emission are of significance.

(2610) H. Funk, *Darstellung der Metalle im Laboratorium,* Enke, Stuttgart, 1938. The production of the rarer metals in the laboratory is described. A special method to produce chromium, as developed by E. Glatzel, is discussed on p. 65.

(2611) M. Littmann, *Getterstoffe und ihre Anwendung in der Hochvakuumtechnik.* Wintersche Verlagsbuchhandlung, Leipzig, 1938. The principles of getterizing are described, and various getter materials, notably the rarer refractory metals, *e.g.*, thorium, titanium, zirconium and tantalum are discussed.

(2612) Several Qualities of Pure Titanium. W. Kroll, *Metallwirtschaft, 18,* 77-80 (1939). The corrosion resistance of Ti is comparable with that of 18-8 steel.

(2613) Metals as Getters. J. D. Fast, *Philips Techn. Rev., 5,* No. 7, 217-221 (1940). Zirconium, in the form of powder or sheet, is used as a getter material.

(2614) Some Features of Ductile Zirconium and Titanium. H. W. Gillett, *Foote Prints, 13,* No. 1, 1-11 (1940). The massive metal may be produced from powder in an evacuated Pyrex bulb, having a side tube containing iodine; a hair pin wire made of Zr or Ti is sealed into the bulb.

(2615) Magnetic and X-Ray Studies on Titanium and Zirconium with Dissolved Hydrogen. J. Fitzwilliam, A. R. Kaufmann, and C. F. Squire. *J. Chem. Phys., 9,* 678-82 (1941). Hydrogen, dissolved in Ti, changes the lattice from hexagonal close-packed to a nearly cubic face-centered lattice.

(2616) Magnetic Susceptibility of Titanium and Zirconium. C. F. Squire and A. R. Kaufmann, *J. Chem. Phys., 9,* 673-7 (1941). The susceptibility of Ti increases linearly from 20 to 1200° K.

(2617) Applications of Zirconium. *Rev. brasil., 13,* 99-103 (1942). Zr for filaments described.

(2618) Zirconium - An Abundant "Rare" Metal. W. M. Raynor, *Foote Prints, 15,* 2-3, 10 (1943). Gives information on Zr-powder, ductile massive Zr, corrosion resistance and uses.

(2619) Powdered Rare Metals Followed on Flow Sheet. E. J. Wellauer, *Metals Rev., 16,* No. 3, 3 (1943). Report on talk by C. C. Balke in Milwaukee. Advantages of products made from powders pointed out with help of flow sheet.

(2620) Zirconium Metal, Its Manufacture, Fabrication and Properties. D. B. Alnutt and C. L. Scheer, *Trans. Electrochem. Soc., 88,* 195-205 (1945). Major improvements in processes for purifying Zr metal are traced down to the present methods which produce both powdered and massive metal of high purity.

(2621) Use of Zirconium in the Vacuum Tube. A. N. Rogers, *Trans. Electrochem. Soc., 88,* 207-213 (1945). Relative merits of binders and of various techniques of coating tube elements with the finely divided metal or hydride discussed.

(2622) Ductile Titanium. *Metal Ind. (London), 69,* No. 1, 7, 58 (1946). Preparation and properties of the massive metal are described.

(2623) Preparation and Properties of Ductile Titanium. R. S. Dean, J. R. Long, F. S. Wartman and E. L. Anderson, *Trans. Am. Inst. Mining Met. Engrs., 166,* 369-381 (1946). Method of preparing metallic Ti, experimental work, leaching and grinding, efficiencies, product purity, and control, powder metallurgy, sintering, fabrication, properties of Ti, resistance to corrosion, summary.

(2624) Ductile Titanium — Its Fabrication and Physical Properties. R. S. Dean, J. R. Long, F. S. Wartman and E. T. Hayes, *Trans. Am. Inst. Mining Met. Engrs., 166,* 382-398 (1946). Consolidation of the powder; fabrication of sintered materials; effects of cold rolling; hot rolling; rod and wire; summary.

(2625) Metallic Titanium and Alloys. R. S. Dean and B. Sikes, *U. S. Bur. Mines Inform. Circ., 7381,* 1946, 38 pp. Titanium industry based on titanium-dioxide production from ilmenite. Production of the powdered metal and fabrication and properties of massive, ductile titanium.

(2626) J. De Ment and H. C. Dake, *Rarer Metals.* Chemical Pub. Co., New York, 1946. Data on beryllium, gallium, indium, thallium, titanium, zirconium, hafnium, thorium, molybdenum, tungsten, and uranium are given.

(2627) Production and Uses of Rare Metals. W. J. Kroll, *Mining and Met., 27,* No. 5, 262-66 (1946). Fundamental research on rare metals is urged to provide knowledge stockpile for future use.

(2628) Titanium and Zirconium: Two Metals of the Future. W. J. Kroll and A. W. Schlechten, *Metal. Ind. (London), 69,* No. 16, 319-20 (1946). Large scale preparation of titanium depending on reduction of pure titanium tetrachloride with magnesium in furnace with argon or helium protective atmosphere. Preparation of zirconium is similar, except for the need to overcome difficulties associated with sensitiveness of metal to O and N. Production and properties of the massive, ductile metals are discussed.

(2629) Ductile Zirconium from Zircon Sand. W. J. Kroll, A. W. Schlechten and L. A. Yerkes, *Trans. Electrochem. Soc., 89,* 263-76 (1946). Zirconium metal is processed from powder produced by reduction of the chloride with Mg.

(2630) Titanium Produced by Degussa and Osram. J. S. Smalko, F.I.A.T. Rept. No. 798, 1946. Degussa made titanium, though it was contaminated with Fe from the reaction vessel, by reducing titanium tetrachloride with molten sodium. Osram made titanium by thermal decomposition of titanium bromide on hot tungsten filament, and by reduction of titanium dioxide with calcium hydride. Massive, ductile metal produced by both methods.

(2631) Three German Methods of Producing Titanium. *Metal Ind. (London), 70,* No. 19, 363 (1947). Methods employed by Degussa involve reduction of titanium tetrachloride with sodium metal, while Osram used reduction of titanium dioxide with calcium hydride, or a thermally decomposed titanium bromide, to produce very pure metal. All products could be processed into the massive, ductile metal.

(2632) Recent Development in Rare Metals. *Steel, 120,* No. 14, 93 (1947). Advances in technology of thorium, uranium, zirconium attributed to the development of metals of high purity.

(2633) Spot Welding of Titanium. R. S. Dean, J. R. Long, E. T. Hayes and D. C. Root, *Trans. Am. Inst. Mining Met. Engrs., 171,* 431-38 (1947). Experimental work covers surface treatment, welding current and time, and effect of pressure.

(2634) C. S. DuMont, *Bibliography on Titanium,* Battelle Memorial Inst., Columbus, Ohio, 1947, 180 pp. Raw materials, preparation of the ductile metal, properties and applications are covered.

(2635) Titanium, Some Properties and Applications. H. W. Greenwood, *Metallurgia, 36,* 44-45 (1947). Role of titanium in metallurgy; available forms.

(2636) Recent Progress in Malleable Zirconium. W. J. Kroll, A. W. Schlechten, W. R. Carmody, L. A. Yerkes, H. P. Holmes, and H. L. Gilbert. *Trans. Electrochem. Soc., 92,* 99-113 (1947). Production of zirconium from zircon sand by use of a vacuum-arc furnace is described; metal can be used for making zirconium carbide which is then converted into zirconium metal.

(2637) Preparation of Zirconium. W. C. Lilliendahl and H. C. Rentschler, *Trans. Electrochem. Soc., 91,* 285-99 (1947). Experimental equipment for production of rare metals and especially Zr.

(2638) A Survey of German Research Work on Titanium. A. D. McQuillan, C. S. M. Duggan and M. K. Petch, B.I.O.S. Final Rept., 1179, 1947, 20 pp.; *Met. Powd. Rept., 1,* No. 10, 155-156 (1947). The Osram Co. made 95% pure Ti from the hydride by reducing TiO_2 with CaH_2, then sintered and partially or wholly impregnated with Ca or Mg. The alloys could be cold-rolled. By other methods the sintered bars were melted in calcium oxide crucibles or in a tungsten arc under vacuum.

(2639) Radio Valves. E. R. Owen, B.I.O.S. Final Rept. No. 276, 1947, 16 pp.; *Met. Powd. Rept., 1,* No. 1, 11 (1947). Special materials for radio valves by Telefunken Gesellschaft für Drahtlose Telegraphie; manufacture of thorium sheet, rod and wire from powder; coatings of iron and nickel valve parts with thorium and zirconium.

(2640) Zirconium and its Application. W. M. Raynor, *Mining and Met., 28,* No. 486, 284-85 (1947). Zirconium possesses many characteristics that would make its general use of great benefit. This bright tarnish-proof metal is more abundantly distributed than copper or lead.

(2641) D. M. Yost, H. Russell and C. S. Garner, *Rare-Earth Elements and Compounds,* Wiley, New York, 1947, 92 pp. Chap. 6: Chemical and physical properties and preparation of rare-earth elements.

(2642) Physical Properties of Titanium Alloys. *Iron Age, 162,* No. 26, 101-2; No. 27, 41-43 (1948). The Office of Naval Research held a symposium on Ti at which 17 papers were presented, some dealing with the sintered metal and its alloys.

(2643) Titanium. *Metal Bull. No. 3331,* 15 (1948). E. I. du Pont de Nemours & Co. have started the production of ductile titanium in sponge form at Newport plant.

(2644) Preparation and Properties of Pure Titanium. I. E. Campbell, R. I. Jaffee, J. M. Blocher, Jr., J. Gurland and B. W. Gonser, *Trans. Electrochem. Soc., 93,* 271-285 (1948). Ductile, high-purity, massive Ti is produced in 300-600 gram lots in a special glass unit by decomposing iodide, formed by action of iodine vapor upon the crude metal on a hot filament; the properties of compact metal are described.

(2645) New Getter Materials for the High Vacuum Technique. W. Espe, *Powder Met. Bull., 3,* No. 5, 100-111 (1948). Coating getters include Ta, Zr, Th, and the so-called "Ceto" getters (a mixture of cerium and thorium powders). A flash getter discussed is the "Bato" type, consisting of 50-50 Al-Ba master alloy powder to which Al_2O_3 and Th is admixed in an approximate ratio of 10:1:30.

(2646) Metals Difficult to Prepare. J. D. Fast, *Met. Powd. Rept., 2,* No. 12, 192 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 192 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 20. The author deals first with the solubilities of O and N in Ti, Zr, V and Os. The powders of these metals were transformed into their iodides, which were decomposed on an annealed wire. Mo and Zr are produced in U.S.A. by melting.

(2647) Metallic Titanium is Light, Strong, Durable. E. A. Gee, J. R. Long and W. H. Waggaman, *Materials & Methods, 27,* No. 1, 75-78 (1948). Supply of raw material, manufacture of titanium metal, its physical properties and corrosion resistance are discussed and the uses of ductile titanium reviewed.

(2648) Titanium, A Modern Metal. J. J. Harwood, *J. Am. Soc. Naval Engrs., 60,* No. 4, 443-60 (1948). Preparation of ductile Ti; properties and uses. Government programs; industrial research.

(2649) Titanium Takes New Importance. O. Herres, *Mines Mag. (Colo.), 38,* No. 4, 19-20 (1948). Various new industrial uses, production and research are discussed.

(2650) Symposium on Titanium. E. S. Kopecki, *Iron Age, 162,* No. 26, 101-03 (1948). A review is given of the symposium sponsored by the Office of Naval Research in Washington on December 16, 1948. The symposium included several papers dealing with the powder metallurgy of titanium.

(2651) Rare Metal Metallurgy. W. J. Kroll, *Metal Ind. (London) 73,* 263, 283, 307, 310, 323, 325 (1948). Special production methods for less-common elements must be examined from various viewpoints: the reducing agent, the components to be reduced, the volatility of both, the fusibility of the reaction products, the methods for separation, the heats of formation of compounds and the processing into useful forms and objects.

(2652) Production of Thorium, Zirconium, Uranium. G. Meister, *Metal Progress, 53,* No. 4, 515-520 (1948). Th, Zr, U have been studied by Westinghouse Electric Corp. for 20 years, for its use in electron tubes.

(2653) Titanium and Zirconium in Australia. H. W. Worner, *Chem. Eng. Mining Rev., 40,* 254-255 (1948). Comprehensive statement about properties and uses of Ti and Zr, and proposals for developing their resources in Australia.

(2654) Properties of Titanium and Titanium Alloys. *Metal Progress, 55,* No. 3, 345-68 (1949). Fatigue and corrosion of sintered and rolled Ti; engineering properties of binary sintered and rolled Ti alloys.

(2655) Our Next Major Metal – Titanium. *Product Eng., 20,* No. 11, 129-52 (1949). A comprehensive summary of its position with information by all leading U. S. laboratories. Refers also to powder metallurgy products.

(2656) Titanium and Titanium Alloys. *Steel, 124,* No. 25, 100-104; No. 26, 58-61, 92, 94 (1949). Recent findings on production properties and application of the pure metal, as reported by leading authorities, are reviewed. Reference is made to the powdered raw material and to the powder metallurgy of titanium.

(2657) Tensile Strength of Titanium at Various Temperatures. R. L. Bickerdike, and D. A. Sutcliffe, *Metallurgia, 39,* 303-4 (1949). Test bars of sintered, cold-

worked Ti with 0.27% O and 0.09% N had tensile strength at room temperature, 300° C. (570° F.), and 500° C. (930° F.) of 82,200, 34,600, and 24,400 psi, respectively.

(2658) Zirconium Widens Its Industrial Orbit. W. B. Blumenthal, *Chem. Inds., 65,* No. 5, 728-30 (1949). Growth in production and use; entire production of zircon in United States during recent years has been in Florida; principal consumption is in refractories, ceramics and metallic alloys, but it is finding widening chemical uses in textile, leather and pigments fields.

(2659) Progress in Titanium Told at Naval Research Symposium. T. C. Du Mond, *Materials & Methods, 29,* No. 2, 45-47 (1949). An account is given of some important recent findings about the production, properties and possible applications of the metal. The powder metallurgy of titanium is included in the considerations.

(2660) Manufacture of Ductile Thorium. W. Espe, *Powd. Met. Bull., 4,* No. 1, 17-18 (1949). Report on powder metallurgy production methods developed during war in Germany; preparation of thorium powder; preparation of pressed bars; rolling of thorium sheet; manufacture of thorium bars and wires; working and machining.

(2661) Titanium. B. W. Gonser, *J. Metals, 1,* No. 1, Sect. 1, 6-9 (1949). Occurrence and ores and process metallurgy are reviewed, and the iodide process is emphasized. Physical metallurgy, properties, and uses are also surveyed.

(2662) Production of Titanium by Iodide Process. B. W. Gonser, *Metal Progress, 55,* No. 2, 193-94 (1949). The process and equipment are described. Production and properties of the massive metal.

(2663) Production and Properties of Iodide Titanium. B. W. Gonser, *Titanium Symposium,* Off. Naval Res., Washington, D.C., 1949, pp. 60-69. Discussion of background of the process, current production equipment, and the purity, metallographic structure, and properties of iodide titanium metal.

(2664) Thermal and Electrical Properties of Ductile Titanium. E. S. Greiner and W. C. Ellis, *Trans. Am. Inst. Mining Met. Engrs., 180,* 657-65 (1949). Tests were made on worked and annealed sintered compacts from powder developed by the U. S. Bureau of Mines.

(2665) Some Effects of Heating Zirconium in Air, Oxygen and Nitrogen. E. T. Hayes and A. H. Roberson, *Trans. Electrochem. Soc., 96,* 142-51 (1949). Zr metal was heated in N_2, O_2, and air at temperatures ranging from 425 to 1300° C. Gain in weight, micro- and macrohardness and metallographic structures were noted. N_2 diffuses into Zr at a much slower rate than O_2. A marked difference in penetration of both gases was found near 900° C., and this is evidently associated with the allotropic transformation from hexagonal to cubic form. Practical limits for the heating of Zr in air, O_2 and N_2 are given and the possibilities of producing hard-surface coatings are discussed.

(2666) Zirconium Metal, as of 1949. R. I. Jaffee, *J. Metals, 1,* No. 7, Sect. 1, 6-9 (1949). A summary of the properties of zirconium as made by the iodide, Kroll and Westinghouse processes.

(2667) Titanium — Its Properties and Prospects. R. I. Jaffee and I. E. Campbell, *Iron Age, 164,* No. 4, 48-51 (1949). The article summarizes the titanium position; it includes references to powder metallurgy of titanium.

(2668) Some Properties of Uranium. A. R. Kaufmann, *Metal Progress, 56,* No. 3, 386, 390, 392, 399 (1949). Uranium fluoride can be reduced with metallic magnesium or calcium; the resultant particles can be fused together to yield the metal in massive form. Powder metallurgy methods were not too satisfactory.

(2669) Melting and Casting Zirconium. W. J. Kroll and H. L. Gilbert, *Trans. Electrochem. Soc., 96,* 158-69 (1949). Briquetted powder is used in part of the work.

(2670) Properties of Iodide Titanium. F. B. Litton, *Titanium Symposium,* Off. Naval. Res., Washington, D.C., 1949, pp. 70-72. The composition and impurities of Foote's iodide Ti are given; also the tensile properties of sheets.

(2671) Composition, Structure and Properties of Iodide Titanium. F. B. Litton and B. W. Gonser, *Metal Progress, 55,* No. 3, 346-47 (1949). Comparison between the massive metal products from iodide Ti and magnesium-reduced Ti.

(2672) Fabrication of Titanium and Investigations of Titanium-Nickel Alloys in the Bureau of Mines Laboratories. J. R. Long, *Titanium Symposium,* Off. Naval Res., Washington, D. C., 1949, pp. 27-46. Discusses the consolidation of titanium powder and presents a tentative Ti-Ni diagram.

(2673) Production of Ductile Zirconium. G. L. Miller, *Inst. of Mining and Metallurgy, Symposium on Refining of Non-Ferrous Metals,* Paper No. 19, 1949, 12 pp. The author describes the iodide and the Kroll processes. A large Kroll plant is under construction, but the author believes that further improvements could be made in the iodide process.

(2674) Problems in Production of Some Rarer Metals. A. R. Powell, *Inst. of Mining and Metallurgy, Symposium on Refining of Non-Ferrous Metals,* Paper No. 4, 1949, 15 pp. In this review, powder metallurgy figures to a certain extent in the production of rhenium, vanadium, titanium and zirconium.

(2675) Engineering Properties of Sintered and Rolled Titanium. N. E. Promisel, *Metal Progress, 55,* No. 3, 354-55 (1949). Stress-strain curves; flexural fatigue of Ti sheet; strength of welds in Ti sheet.

(2676) Microstructure of Uranium. H. P. Roth, *Metal Progress, 56,* No. 5, 662-663 (1949). Photomicrographs are shown of the metal in various stages of working.

(2677) Production and Arc Melting of Titanium. O. W. Simmons, C. T. Greenidge, and L. W. Eastwood. *Titanium Symposium,* Off. Naval Res., Washington, D. C., 1949, pp. 77-91. The furnace arrangements at Battelle Memorial Institute are described.

(2678) Induction Melting of Titanium in Graphite. J. B. Sutton, *Titanium Symposium,* Off. Naval Res., Washington, D. C., 1949, pp. 73-76. A description is given of the melting and casting equipment developed by E. I. du Pont de Nemours & Co., which utilizes crushed sponge.

(2679) Fatigue and Corrosion of Sintered and Rolled Titanium. W. L. Williams and W. C. Stewart, *Metal Progress, 55,* No. 3, 351-54 (1949). Ti bar stock gave a fatigue limit of 30,000 psi, with the ratio of fatigue limit to tensile strength being 0.31. Tests were also conducted to determine notch sensitivity, alternating torsion fatigue and flexural fatigue. The Ti was corrosion tested in salt water, and despite severe test conditions, the metal was scarcely damaged. This property, together with its other unique properties, may make Ti extremely attractive to the Navy.

E. Refractory metal alloys and composites

(2680) The Production of Alloys of Tungsten and Molybdenum in the Electric Furnace . C. I. Sargent, *J. Am. Chem. Soc., 22,* 783 (1901). A description is given of a number of tungsten-chromium alloys.

(2681) Alloys of Manganese and Molybdenum. G. Arrivant, *Compt. rend., 143,* 285, 464 (1906). Mo and Mn powders are mixed in different relations to form Mn_6Mo and Mn_4Mo after compaction and heating.

(2682) Tungsten Alloys. A. Polster, *Tech. Rundschau, 38, 278-280* (1915). Tungsten-lead and tungsten-lead-antimony composite alloys are suggested for projectiles because of their exceptionally high specific gravity.

(2683) Tungsten-Molybdenum Alloys. Z. Jeffries, *Bull. Am. Inst. Mining Eng.,* No. 114, 1049-59 (1916). A wire of the alloy is examined by stretching between electrodes in H atmosphere, and a current is passed until the wire melts; the required watts are observed.

(2684) Tungsten-Molybdenum Equilibrium Diagram and System of Crystallization. Z. Jeffries, *Bull. Am. Inst. Mining Engrs., No. 115,* 1225-43 (1916). The melting point of tungsten in lowered by the addition of Mo.

(2685) The System Tungsten-Molybdenum. F. A. Fahrenwald, *Trans. Am. Inst. Min. Met. Engrs., 56,* 612-19 (1917). By compressing the mixed reduced powders into briquets and then heating in hydrogen, alloys were prepared of varying W and Mo contents.

(2686) Highly Refractory Metals. F. A. Fahrenwald, *Trans. Am. Electrochem. Soc., 30,* 357-60 (1917). The W-Mo system is investigated for testing a binary system of intermetallic compounds with melting points far above those of their components.

(2687) Tungsten-Lead Alloys. K. Inouye, *Mem. Coll. Sci. Kyoto Imp. Univ., 4,* 43-46 (1919). A study was made of the freezing point curve for lead-tungsten alloys.

(2688) X-Ray Investigation of Alloys. K. Becker and F. Ebert, *Z. Physik, 16,* 165-169 (1923). An investigation was carried out on W-Ni alloys. It was found that an alloy containing 60% Ni is non-magnetic when the ingot is sintered only, but magnetic when it is fused.

(2689) Binary System Tungsten-Molybdenum. W. Geiss and J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 128,* 355-60 (1923). The melting point of the alloy was determined by sintering the compressed mixture of the metal powders forming filaments of known cross-section and measuring the current to produce fusion.

(2690) Chromium-Molybdenum and Chromium-Molybdenum-Copper Alloys. E. Siedschlag, *Z. anorg. allgem. Chem., 131,* 191-96 (1923). The chromium-molybdenum alloy system was investigated, and the alloys were produced from powders.

(2691) Molybdenum-Thorium Alloys. A. Gehrts, *Helios Fach-Z. Elektrotechnik, 33,* 471-74 (1927). Alloys that can be used for cathodes can be produced by pressing a mixture of the pure elemental powders and sintering in vacuum at temperatures near the solidus; the resulting material is sufficiently ductile to be worked into wire.

(2692) Alloys as Substitutes for Diamond Dies. A. Drebes, *Iron Age, 122,* No. 7, 392 (1928). An alloy containing 75-95% W and 25-5% Co is made from a mixture of tungstic acid and cobalt oxide, Al powder is used as reaction material. That die is cheaper than diamond die, and more durable than steel die.

(2693) The Tempering of Wires from Mixed Crystals. C. Agte and K. Becker, *Z. tech. Phys., 11,* 107-111 (1930). The tensile strength of tungsten and alloys of tungsten with molybdenum and tantalum was investigated.

(2694) Tungsten-Rhenium Alloys and Their Constitution. K. Becker and K. Moers, *Metallwirtschaft, 9,* 1063-66 (1930). The melting points of W-Re alloys were determined.

(2695) Relations between Changes in Physical Properties by Cold-Working and Formation of Solid Solutions. C. Agte and K. Becker, *Physik. Z., 32,* No. 2, 65-80 (1931). The investigation involved the systems W-Mo and W-Ta.

(2696) Tungsten-Molybdenum Alloys. J. A. M. Van Liempt, *Rec. trav. chim., 51,* 114-17 (1932). The rate of diffusion of W and Mo into each other was found to be faster in polycrystalline than in single crystal wires.

(2697) X-Ray Investigation of Zirconium Tungstide. W. G. Burgers and A. Claassen, *Z. Krist., 86,* 100-105 (1933). A tungsten-zirconium alloy was formed by depositing metallic Zr on a W filament heated in the vapor of ZrI, and subsequently heating the filament to a higher temperature.

(2698) Tungsten Alloy Used to House Radium. *Science, 82,* No. 2127, 320 (1935). An alloy of density of 1.5 times to lead is used to house the 4 g. of radium at the Westminster hospital.

(2699) An Application of New Dense Tungsten Alloy in Teleradium Therapy. L. G. Grimmett, and J. Read, *Brit. J. Radiology, 8,* 661-65 (1935). The production of a tungsten alloy of 16.5 g./cm.^{2} density is described.

(2700) A New Alloy, Especially Suitable for Use in Radium-Beam Therapy. J. C. McLennan and C. J. Smithells, *J. Sci. Instruments, 12,* 159-60 (1935). W, Ni, and Cu alloy is formed of mixed powders, pressed and sintered in hydrogen.

(2701) Measurement of Saturation Currents on Glowing Cathodes. E. Patai and G. Frank, *Z. tech. Phys., 16,* 254-62 (1935). Tungsten-molybdenum alloys are described in their application as core wires for oxide paste cathodes.

(2702) Alloys of Malleable Chromium. W. Kroll, *Z. Metallkunde, 28,* No. 10, 317-19 (1936). Influence of Fe, Ni, Co, Al, Si, Mo, W, V, Ti, Zr and Ta on the malleability of sintered and worked chromium. Structural examinations by microscope and x-ray conducted on the materials in various stages of production; hardness tests as means of determining effect of intermediate and final annealing treatments on the hot-rolled sheets.

(2703) A New Alloy of High Density. P. Bergsøe, *Nature, 139,* 886 (1937). Produced from W, Cu and Ni powders, with W content of about 90%.

(2704) Malleable Alloys of Titanium. W. Kroll, *Z. Metallkunde, 29,* 189-92 (1937). Alloys prepared from sintered compacts of mixtures of titanium and other powders.

(2705) A New Alloy of High Density. C. J. Smithells, *Nature, 139,* 490-1 (1937). Preparation of W-Ni-Cu alloy.

(2706) Sintered Alloys I: Copper-Nickel-Tungsten Alloys Sintered with Liquid Phase Present. G. H. S. Price, C. J. Smithells, and S. V. Williams, *J. Inst. Metals, 62,* 239-264 (1938). The copper-nickel-tungsten system. Preparation of the alloys, effect of temperature and time of sintering effect of tungsten particle size, pressure and composition. Mechanism of sintering discussed. Physical properties of W-Ni-Cu alloys. Other systems of related characteristics, such as Ag-Cu, Fe-Cu, and W-Co-Ag.

(2707) Sintered Copper-Nickel-Tungsten Alloys. G. H. S. Price, C. J. Smithells, and S. V. Williams, *Ind. Heating, 5,* 500-2, 548 (1938). Description of "Heavy Alloy" type of material, containing about 90% W, 6% Ni, 4% Cu.

(2708) Constitution of Chromium-Molybdenum Alloys. W. Trzebiatowski and H. Ploszek, *Naturwissenschaften, 26,* 462-464 (1938). Sintered alloys were examined. As raw material, electrolytic Cr (1% oxide content) and high purity Mo powders were used.

(2709) Nickel-Columbium Alloys by Reduction of Columbium Pentoxide in the Presence of Nickel. G. Grube, O. Kubaschewski and K. Zwiauer, *Z. Elektrochem., 45,* 881-84 (1939). The reduction of mixtures of columbium pentoxide and nickel powders by hydrogen resulted in practically oxygen-free alloy powders which were then pressed and sintered at 1100-1150° C. (2000-2100° F.) in hydrogen.

(2710) Manufacture of Non-Porous Alloys from Powders. W. D. Jones, *Metal Treatment, 5,* No. 17, 13-16 (1939). Tungsten-copper-nickel high density alloy, cold pressed and heat-treated to a temperature giving maximum shrinkage.

(2711) New Material from Heavy Alloys. K. Meier, *Z. Ver. deut. Ing., 83,* 1094-96 (1939). Applications for heavy alloys are cited, *viz.*, balancing parts on gyroscopes and electrical contacts.

(2712) Alumino-Thermic Production of Chromium-Tungsten Alloys. F. Weibke, and U. v. Quadt, *Z. Elektrochem., 46,* 635-41 (1940). Reference is made to the analytical investigation, the testing, and the composition of Cr-W alloys.

(2713) G. E. C. Heavy Alloy Made by Sintering Tungsten-Powder with Copper and Nickel. *Metallurgist* (Suppl. to *Engineer*), *13,* 39-40 (1941). In alloys containing Ni and Cu two factors are of importance: the ratio of Ni to Cu, and the total percentage of these metals present, fixed at 10%. Cu lowers the melting point of Ni, and thus ensures the presence of the liquid phase.

(2714) Radium Containers of High Density Metallic Aggregates. H. F. Kaiser, *Metals & Alloys, 14,* No. 2, 170-2 (1941). Metal shipping container of tungsten-base alloys ("Heavy Metal") described.

(2715) Heavy Alloy. Its Production, Properties and Uses. G. H. S. Price, S. V. Williams, and G. J. O. Garrard, *Metal Ind. (London), 59,* 354-55, 372-73, 394-95 (1941); *J. Gen. Electric Co. (London), 11,* No. 4, 223-30 (1941). W-Cu-Ni alloys of different compositions.

(2716) The Systems Chromium-Tungsten and Chromium-Molybdenum. O. Kubaschewski and A. Schneider, *Z. Elektrochem., 48,* 671-74 (1942). The fact that chromium and molybdenum are completely soluble and chromium and tungsten are mostly soluble is demonstrated on sintered alloys.

(2717) Heavy Alloy – Its Production, Properties and Uses. G. H. S. Price, S. V. Williams and G. J. O. Garrard, *Metal Progress, 41,* No. 3, 337, 406, 414 (1942). W-Cu-Ni alloys of different compositions.

(2718) Some Modified "Heavy Metal" Alloys – Effect of Composition on Properties. H. H. Hausner, *Metals & Alloys, 18,* No. 6, 1335-1338 (1943). Applications of W-Ni-Cu compound materials, processing, properties, electrical and mechanical. Materials described have lower W-content and density than Smithell's heavy metal.

(2719) Screening Materials for Use in Industrial Radiography. G. H. S. Price, *Metal Ind. (London), 63,* No. 22, 338-9 (1943). Production of high W-alloys by pressing and sintering metal powders for use in screening of gamma-rays.

(2720) Early Days of Nickel-Tungsten Metallurgy. M. Pirani, *Trans. Electrochem. Soc., 85,* 163-8 (1944). Method is described for production of fine Ni-W wires by cold rolling and drawing well sintered, pressed mixture 90% to 94% fine W powder and 10-6% Ni powder. Processes were carried out in 1907 and 1909.

(2721) A New Mass-Balance Alloy. *Aeroplane, 70,* No. 1, 11 (1946). Produced by General Electric Co., the alloy contains 90% W, balance Ni and Cu, and the mixed powders are obtained by sintering at 1450° C. (2640° F.).

(2722) New Products and Materials – High Density Alloys. *Chem. & Met. Eng., 53,* No. 7, 153 (1946). Produced by powder metallurgy a series of high density alloys has recently been announced by the Callite Tungsten Corp. Three general types are available. Type P composed of W, Cu, Ni and small percentage of other ingredients; Type E consists mainly of W, Co, Ag; Type Y consists of W, Co, Ni.

(2723) Tungsten Firm Develops High Density Alloys. *Iron Age, 157,* No. 26, 151 (1946). Callite Tungsten Corp. announces "Dense Alloy 112" is available in three general types: type P, type E, type Y.

(2724) Tungsten Alloy and Its Uses. *Machinery (London), 68,* No. 1751, 566-567 (1946). "Heavy alloy" has a 90% W base with addition of Cu or Ni. The three mixed metal powders are compacted at 10,000 psi and sintered at 1450° C. (2640° F.).

(2725) Properties and Uses of "G.E.C. Heavy Alloy". *Monthly Science News,* No. 2, 2-3 (1946). G.E.C. Heavy alloy has been extensively used for balancing control surfaces in aircraft and for balancing crankshafts of aero-engines.

(2726) Alloys of Heavy Metals. G. Fitzgerald-Lee, *Aircraft Eng., 18,* No. 209, 239-41 (1946). GEC Heavy Alloy manufactured in England. Materials as strong as steel consist of 90% W alloyed with Ni and Cu. Mixed powdered pressed and sintered at approx. 1450° C.

(2727) Sintered High-Density Tungsten and Tungsten Alloys. J. Kurtz, *Proc. Sec. Ann. Spring Meeting of Met. Powd. Assoc.,* New York, June 13, 1946, 40-52 (1946). Alloys containing approx. 85-90% W, balance Ni and Cu, or Co and Ag are mainly discussed; also mentioned are pure W and pure Mo.

(2728) Heavy Alloy Aids Machine Design. G.H.S. Price, *Iron Age, 158,* No. 12, 62-63 (1946). Material equally as strong as steel has twice the density. High-tungsten powder metallurgy product specifically intended for use in cases where moving parts must be balanced, yet space conserved. Physical properties of material and applications described.

(2729) Powdered Alloy Has Strength and Density Near That of Tungsten. *Materials & Methods, 26,* No. 2, 143 (1947). Description of sintered alloy

Mallory 1000, developed by P. R. Mallory & Co., Inc., Indianapolis, Ind., has modulus of elasticity of 20,000,000-40,000,000, and is atmosphere and corrosion resistant; it is of the "heavy alloy" type.

(2730) Tungsten-Copper-Nickel Alloy has Great Density. *Steel, 121,* No. 25, 88 (1947). Alloy of W-Cu-Ni has density 50% greater than lead and is developed by Metallurgy Div. of General Electric Co., Pittsfield, Mass.

(2731) Physical Properties of Tungsten-Copper-Nickel Compacts. H. H. Hausner, *Powd. Met. Bull., 2,* No. 1, 6-11 (1947). Volume change, reduction in thickness, density, electrical conductivity, and hardness results are listed.

(2732) Electron Diffraction Study of Oxide Films Formed on Molybdenum, Tungsten and Alloys of Molybdenum, Tungsten and Nickel. J. W. Hickman and E. A. Gulbransen, *Trans. Am. Inst. Mining Met. Engrs., 171,* 371-388 (1947). Survey of literature, experimental procedure and results.

(2733) Heavy Alloys. G. H. S. Price, *Indian Eng., 121,* No. 1, 42-43 (1947); *J. Inst. Metals (London), 15,* 105 (Abstr.) (1947). Heavy alloys developed by General Electric Co. Product of powder metallurgy containing 90% W with Ni and Cu. Alloy can be machined, used in aircraft for flight control surfaces and in gyroscopes.

(2734) Pyrophoric Alloy. E. Raub and M. Engel, *Metallforschung, 2,* No. 4, 115-9 (1947). Sintered thorium-silver compacts are subjected to spontaneous ignition; silver is acting as catalyst in the oxidation of thorium.

(2735) Sintering of Tungsten and Copper Oxide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3918/47 (1947). According to this report of 1942, mixtures of tungsten and copper oxide could not be sintered satisfactorily.

(2736) Hevimet-Corrosion Resistant Alloy. *Chemical Process, 11,* No. 3, 21 (1948). Hevimet, alloy of tungsten, copper, and nickel, is sintered in a variety of non-porous sheets. Complex shapes built up from simple pressings by process of hydrogen welding.

(2737) New Alloy 50% Heavier Than Lead. *Inco, 22,* No. 3, 14, 29 (1948); *Nuclear Sci. Abs. 2,* 158 (1949). The new alloy, known as G. E. - Hevimet, is produced by powder metallurgy, and has high strength used as screen against rays from radium or x-rays.

(2738) Sintered Alloy of High Density. *Machinery (N. Y.), 54,* No. 7, 196 (1948). An alloy of W, Cu, and Ni, known as G. E. Hevimet is produced by General Electric Co.

(2739) Platinum-Tungsten Alloy. R. I. Jaffee and H. P. Nielsen, *Trans. Am. Inst. Mining Met. Engrs., 180,* 603-15 (1948). Pt-W alloys produced by powder metallurgy are investigated over a range of 25-100% W. The solidus of Pt-W alloys is influenced considerably by purity. Higher W-alloys are hard, brittle and non-workable. Addition of Pt to W does not improve the oxidation resistance at 1200° C. (2200° F.)

(2740) The Constitution and Properties of Alloys Containing Tantalum and Columbium. R. H. Myers, *Metallurgia, 39,* No. 230, 57-63 (1948). This review deals with information which is available on alloys containing Ta and Co, to act as a basis for experimental work.

(2741) Some Aspects of the Metallurgy of Titanium Alloys. P. H. Brace, *Titanium Symposium,* Off. Naval Research, 132-43 (1949). Tables are given containing the properties of different Ti alloys.

(2742) Mechanical Properties of Wrought Titanium Alloys Made by Arc Melting or by Sintering. H. C. Cross, *Metal Progress, 55,* No. 3, 356-58 (1949). The effect of O, H, and N on Ti were studied, with hardness and tensile tests proving the strengthening effect of N. The effects of alloying Ti with C, Cr, Mo, W, Co, and Ta were likewise studied. Both hot and cold rolled alloys were tested for tensile strength, yield strength, elongation and hardness. The tests confirm the beneficial effects of C, O, N, Mo, W, and Cr.

(2743) Titanium Base Alloys. H. C. Cross, *Titanium Symposium,* Off. Naval Res., 125-31 (1949). Effects of oxyger, nitrogen and carbon on the mechanical properties of arc-melted and hot-forged Ti. Effects of Cr, Mo, W, Co, and Ta on tensile strength and ductility of Ti.

(2744) High Density Alloy – with Strength and Machinability Developed from Tungsten-Nickel-Copper Combination. G. H. Denny, *Steel, 124,* No. 16, 101-2 (1949). Research carried out by P. R. Mallory & Co., Inc., resulted in improved alloy, Mallory 1000, which has greater strength and machinability, lower hardness and better ductility; alloy is made by powder metal technique; principal applications are in gyro rotors and watch weights.

(2745) Study of Arc-Melted Molybdenum-Rich Chromium-Molybdenum Alloys. H. D. Kessler and M. Hansen. Am. Soc. Metals – Preprint No. 33 for meeting Oct. 17-21, 1949, 24 pp. (1949). Chromium molybdenum alloys containing 60 to 100% molybdenum were arc melted and cast in argon atmosphere; melting method consisted in fusing consumable electrodes made by powder metallurgy; carbon and beryllium investigated as possible deoxidizers; measured lattice parameters check results of other investigators, and body centered cubic alloys show complete solid solubility.

(2746) Ductile Sintered Materials. O. Landgraf, *Metall, 3,* No. 11/12, 184-86 (1949). Production and uses of Silfram containing 30% Ag, 70% W, and 50% Ag, 50% W, and of Cupram containing 15% Cu, 85% W are described.

(2747) Properties of Binary Sintered and Rolled Titanium Alloys. E. I. Larsen, E. F. Swazy, L. S. Busch and R. H. Freyer, *Metal Progress, 55,* No. 3, 359-61 (1949). Contains a table of mechanical properties and electrical resistivity of titanium alloys.

2. HARD METAL COMPOSITIONS AND PRODUCTS

(2748) Cemented Tungsten Carbide. S. L. Hoyt, *General Electric Co. Research Lab. Report No. 535* (1930). A review of its manufacture, properties, and applications.

(2749) Use of W-Carbide and Other Hard Cutting Tool Materials Gaining. C. Sellers, *Iron Age, 128,* No. 25, 1560-3 (1931). Importance of proper grinding is recognized. Silicon carbide abrasives are used. Honing more generally practiced. Method of mounting tools.

(2750) Material for Modern Cutting Tools. I. V. Emmons, *Metal Progress, 24,* No. 6, 35 (1933). A general review.

(2751) Tungsten Carbide. C. G. Fink, *Foote Prints, 6,* No. 2, 1-16 (1933). Application, grinding and sharpening, preparation of cemented carbide; preparation of dense tungsten metal powder and Co-W alloy powder, structure and other properties.

(2752) Powder Metallurgy and Its Application in the Production of Hard Metal. K. Bonthron, *Tek. Tid., Uppl. C, Kemi Bergsvetenskap, 65,* 41-7, 52-6 (1935). Filaments and carbides, particularly those of tungsten, discussed; mechanical properties.

(2753) High-Melting Hard Materials and Their Technical Application. K. Becker, *Hochschmelzende Hartstoffe und ihre technische Anwendung,* 2nd ed., Verlag Chemie, Berlin, 1935. Manufacture, and chemical and physical properties of hard metals and alloys; sintering of alloys, particularly tungsten carbide and cobalt alloys.

(2754) Present Status of Cemented Carbide and Other Modern Cutting Materials. R. D. Prosser, *Am. Soc. Mech. Engrs., Progress Report No. 4,* Subcommittee on Metal Cutting Materials (1935). Types of material, methods of manufacture, cutting speeds, and machine equipment are described.

(2755) New Firth Stirling Plant for Production of Sintered Carbide Tools and Dies. *Ind. Heating, 4,* No. 6, 458-62 (1937). Description of modern plant installation for production of cutting tool bits and dies.

(2756) Sintered Carbides – A Milestone In Metallurgical Progress. *Wire & Wire Products, 12,* 352-3, 356-8 (1937). Sintered carbides and their relation to metallurgy in general.

(2757) Making Firthite Sintered Carbide Tools. M. F. Judkins, *Tool Engr., 6,* 13-14 (1937). Brief outline of powder metallurgy process including raw material forming, presintering and sintering, quality control, etc.

(2758) Cemented Carbides. Z. Jeffries, *Metal Progress, 34,* No. 4, 314-315 (1938). A brief review covering metallurgy and applications.

(2759) New Plant for Cemented Carbide. *Steel, 104,* No. 22, 42-45, 66; *Wire & Wire Products, 14,* No. 6, 328-33, 336-337, 338-340 (1939). Carboloy's new plant for producing cemented carbide tool bits and drawing dies is described.

(2760) Hard Cemented Carbides. G. J. Comstock, *Metal Progress, 36,* No. 4, 437 (1939). A general review covering metallurgy and applications.

(2761) Manufacture of Cemented Carbides. V. Fisher, *Metal Progress, 36,* No. 3, 247-55 (1939). A pictorial story. Complete details for production of tool bits and dies.

(2762) Sintered High-Melting Hard Substances. W. Machu, *Kolloid Z., 88,* 373-384; *89,* 92-104 (1939). A review of patents, pertaining to cemented carbides and their commercial products.

(2763) Cemented or Sintered Hard Carbides. A. Mackenzie, *Metals Handbook,* Am. Soc. Metals, Cleveland, 1939, pp. 909-917. General discussion; powdered constituents, technique and properties. WC, TaC and TiC. Product control methods. Applications; fabrication of dies, tools, wear-resistant parts.

(2764) Tungsten. C. G. Fink, *Metals & Alloys, 12,* No. 4, 419-20 (1940). Cemented carbide developments of composition, properties and cutting tool applications are briefly discussed.

(2765) Extrusion of Metal Powders Is Advanced by New Technique. R. H. Leach, *Steel, 107,* No. 16, 164 (1940). Improved technique of Carboloy Co. to produce rods, spirals and tubes.

(2766) Cemented Carbides. W. G. Robbins, *Tool Engr., 9,* No. 1, 16-18 (1940). Current carbide materials and their uses; development of powder metallurgy during past 15 years.

(2767) Manufacture and Use of Cemented Carbides. H. Burden, *Engineering, 151,* No. 3916, 86-7; No. 3919, 145-7, 150 (1941). Sintering process. Steel-cutting carbides. Application of carbide alloys.

(2768) Studies on High-Speed Tools. H. Hotta, *Tetsu-to-Hagane, 27,* No. 6, 373-404 (1941) (in Japanese); *C. A., 36,* 5743 (1941). Two methods producing sintered tungsten carbide tools: *(1)* a direct production from the powders using a self-recording compression tester; *(2)* a production by sintering after pressing at ordinary temperatures. The effect of grain size on the sintered tool was also studied.

(2769) Quick and Efficient Method of Making Carbide Tools. *Aero Digest, 40,* No. 2, 141 (1942). Buick manufactures own tungsten carbide tools.

(2770) Some Physical and Chemical Properties of Carbides after Final Sintering. E. W. Engle, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 39, pp. 436-453. Manufacture by cold press and sintering or treatment; hot-press method; physical properties; applications.

(2771) Cemented Carbide Manufacture and Applications. A. Mackenzie, *Wire & Wire Products, 17,* No. 10, 574-9 (1942). Powdered W-carbide and Co mixed together and milled until each carbide part has been coated with layer of metal, then 0.5-2% lubricant is added. Pressed at 5-30 tsi and sintered at 1350-1500°C. undergoing shrinkage of 12-20%. Uses of cemented carbides.

(2772) Reclaiming Tungsten Carbide Chips. *Automotive and Aviation Ind., 88,* No. 9, 42 (1943). Reclaiming of W-carbide tool tips by keeping in bath of nitric acid at temperature of about 65° C. (150° F.), and then washing in water. Tip is removed from shank, washed in caustic bath and pulverized. Oxide is reduced. Powder is then dried with additions of paraffin wax and formed, pressed, covered with Al-oxide, presintered, cut to shape and finally sintered.

(2773) Reclaiming Carbide Tool Tips. *Metal Treatment, 10,* 262-265 (1943). Procedure employed at Aircraft Engine Div. of Ford Motor Corp. for the recovery of W-carbide tool tips.

(2774) Hard Metal. H. Kalpers, *Glashütte, 73,* 61-3 (1943); *Chem. Zentr., 19,* 365 (1943). Production of sintered hard metal described. Importance of "Widia" in industry commented upon.

(2775) Importance of Hard Metals. H. Kalpers, *Wien. Chem. Ztg., 46,* 126-9 (1943). Preparation, properties, and uses in cutting tools of tungsten carbide.

(2776) Cemented Carbides. *Automobile Engr., 34,* No. 453, 365-71 (1944). Notes describe methods employed in manufacture of Wimet products, among first of cemented carbide materials made in Great Britain; technique employed by Powderloys Ltd. is described.

(2777) Powder Metallurgy as Applied to Cemented Carbides. W. R. Jackson, *Trans. Can. Inst. Mining Met., 47,* 393-414; Bull. No. 390, Oct. 1944. Manufacture of W-carbide powder and TaC and TiC. Preparation of Co for binder; cold pressing, presintering; sintering; testing physical properties of products; applications; suggestions for care of carbide tools.

(2778) Pressing and Sintering Carbide Tool Tips. W. T. Muirhead, *Metals & Alloys, 19,* No. 2, 368-372 (1944). Detailed description of process of manufacturing carbide tools with pictures.

(2779) Progress in Carbides Fosters Use as a Design Material. K. R. Beardslee, *Steel, 116,* No. 1, 278 (1945). Carbide metal now available in large quantities; therefore, instead of making liners and inserts, entire parts will be made of solid carbide.

(2780) Tungsten Carbides and the Hard Tungsten Alloys. T. R. Bird, *Tungsten,* by C. J. Smithells, Chapman & Hall, London, 2nd ed., 1945, Chap. XII, pp. 234-252. An account is given of the metallography and properties of tungsten carbide and the manufacture and properties of tungsten carbide - cobalt cutting tools and their industrial application.

(2781) Boron Carbide – Hardest Man-Made Material. E. L. Cady, *Materials & Methods, 22,* No. 4, 1058-1063 (1945). Advantages and disadvantages; boron carbide *vs.* diamond dust; solid parts with fine finish; fabrication methods; fastening and assembly practice; applications: gages and parts; blast nozzles and other uses.

(2782) German Cemented Carbide Industry. G. J. Comstock, *Iron Age, 156,* No. 9, 36A-36L (1945). Description of wartime controls set up in Germany; standardization of carbide types for particular applications; production data; advances in hot pressing practices.

(2783) Effect of Cemented Carbides on Product Design. H. Crump and P. Miller *Product Eng., 16,* No. 4, 217-21 (1945). Article presents many possibilities in use of cemented carbides for improving product design by increasing life of parts.

(2784) Cemented Carbides in Australia. R. C. Lister, *Austral. Engr., 44,* No. 346, 33 (1945). Production of cemented carbides in Australia.

(2785) Quality Control and Research on Cemented Carbides. *Machinery (London), 68,* No. 1759, 809-16 (1946). Research laboratories, equipment and facilities employed in connection with manufacture of British-made carbide and products by Hard Metal Tools Ltd. and A. C. Wickman Ltd.

(2786) Hard Metals. A. Cerri, *Bol. inform. petrol. (Buenos Aires), 23,* No. 258, 106-32 (1946). Hard metals, principal physical and chemical characteristics; manufacture of cemented tungsten carbide in Argentina.

(2787) Metallic Carbides and Hard Alloys. W. G. Class, *Ind. Diamond Rev., 6,* No. 12, 376-77 (1946). The work in Russia and France is described.

(2788) Hard Carbides. G. J. Comstock, *Metal Progress, 49,* No. 1, 117-121 (1946). The German cemented carbide industry; plants making carbides; standardized compositions or grades; uses of various grades; improvements in carbide manufacture; hot-pressing of powder.

(2789) Carbides from Powder Metals. J. R. Longwell, *Steel, 119*, No. 23, 130, 159, 162 (1946). Physical properties, characteristics and applications; advantages obtainable in making parts from carbide, of W, Ti, or other metals with metallic binders.

(2790) What Cemented Carbides Offer the Designer. R. K. Lotz, *Machine Design, 18*, 135-137, 184 (1946). Carbides are available in a variety of grades, can be formed to specific shapes to close tolerances, approach the diamond in hardness and offer good general corrosion resistance.

(2791) Cemented Carbide Cutting Tools. H. B. Yuen, *J. Chinese Inst. Engr., 4*, No. 2, 173 (1946). Description of cemented hard carbides; fabrication by powder metallurgy.

(2792) The German Hard Metal Industry. E. Ammann, *Stahl u. Eisen, 66/67*, No. 7/8, 124-126 (1947). Review of the report by G. J. Comstock in *Iron Age, 156*, No. 9, 36 A-L, 1945.

(2793) E. Hirschfeld, *Hard Metals (Tvrdé Kovy)*, 2nd Ed., Práce, Prague, 1947. Survey of hard metals and cemented carbides, their production and application.

(2794) Manufacture of Cemented Carbides. T. A. Hood, *Commonwealth of Australia, Defense Research Labs. Inf. Circ. No. 12*, 1947, 153 pp. This comprehensive literature survey of British, American and German practice was compiled to encourage the development of an Australian carbide industry.

(2795) Cemented Hard Carbide Compositions. P. M. McKenna, *Tool Eng., 18*, 23 (1947). The role of cemented carbide tools in man's progress described.

(2796) Metallurgical Aspects of Cemented Carbides. J. C. Redmond, *Iron Age, 159*, No. 5, 42, 150 (1947). Performance of carbide tools is often as much a matter of manufacturing technique as of chemical components. Various factors such as grain size, porosity and their effects on physical properties are discussed.

(2797) German Hard Metal Industry. C. J. Trapp, B. E. Berry, H. Burden and T. Raine. B.I.O.S. Final Rept. No. 1385, 1947, 453 pp.: *Met. Powd. Rept., 1*, No. 11, 170-172; *2*, No. 4, 55-58 (1947). Extensive review of field investigation. *Cf.* same authors, *Symposium on Powder Metallurgy*, The Iron and Steel Inst., Special Report No. 38, London (1947), pp. 92-98.

(2798) The German Hard-Metal Industry. G. J. Trapp, B. E. Berry, H. Burden, A. E. Oliver and T. Raine; *Symposium on Powder Metallurgy*, The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 92-98; *Met. Powd. Rept., 1*, No. 11, 170-172 (1947). Report on B.I.O.S. trip of Sept.-Oct. 1945. Developments in the techniques of preparing and processing materials in the manufacture of hard-metals in Germany are described. The results of German researches into the structure and physical properties of hard-metals and their constituents are summarized.

(2799) Sintered Carbides. E. M. Trent, *Machinery Market, London, 19*, 2453 (1947). Carbon steels, alloy steels, stellite, *vs.* tungsten carbides; powder metallurgy of cemented carbides.

(2800) Manufacture and Application of Sintered Carbides. E. M. Trent and H. Eckersley, *J. Inst. Product. Engr., 26*, No. 10, 349 (1947). Explanation of nature, production and properties of sintered carbides; use of cemented carbides for various types of cutting tools.

(2801) Equipment for Production of Tungsten Carbide Parts. *Machinery (London), 72*, No. 1848, 398-99 (1948). A complete set of equipment by J. Coltman, Ltd. is described.

(2802) Developments in the Sphere of Hard Metals. E. Ammann, *FIAT Rev. German Sci., 1939-1946:* Ferrous Metallurgy – I, 1948, pp. 341-347. A review with references.

(2803) Cemented or Sintered Carbides. L. Hull and D. L. Schwartz, *Metals Handbook*, Am. Soc. Metals, Cleveland, 1948, pp. 59-63. Preparations of powders; milling and blending; compacting and sintering; control of quality; metallographic examination.

(2804) Increase of Output by Sintered Hard Metals. H. Kalpers, *Industrie u. Technik, 3,* No. 6, 124-28 (1948). The development of sintered hard metals for better chip formation; properties of sintered hard metals; tools with hard metal inserts; working with hard metal tools.

(2805) Manufacture of Sintered Carbides. I-IV. E. M. Trent and H. Eckersley, *Pract. Eng., 17,* No. 420, 134-5; No. 421, 162-3; No. 422, 188-90; No. 424, 230-1 (1948). Manufacture of sintered carbides. Production of sintered components in sintered carbides. Various types of cutting tools. Use of materials in dies and drills.

(2806) Manufacture of Sintered Carbides. *Foundry Trade, 86,* 66 (1949). The Warrington Works of Metropolitan-Vickers Electrical Co. Ltd. has been engaged in the manufacture of sintered carbides under an agreement by which the whole output was sold to Cutanit Ltd.

(2807) Sintered Hard Metals. R. Kieffer, *Einführung in die Pulvermetallurgie.* Technische Hochschule, Graz, 1949, pp. 102-20. Mechanical properties of some hard metals. Properties of sintered and fused WC-Co alloys. Production of sintered hard metals. Uses.

(2808) Hard Metals. G. Patchin and E. Brewin, B. I. O. S. Over-all Rept. No. 15: *Ferrous Metal Industry in Germany, 1939-1945,* 1949, pp. 160-164. A review, with references, of the German industry during the war.

(2809) Cemented Carbides. K. Rose, *Materials and Methods, 29,* No. 2, 73-84 (1949). A considerable amount of data is given which is applicable particularly to American conditions.

(2810) Cast and Sintered Carbides. J. F. Stirling, *Pract. Eng., 19,* No. 485, 530-32 (1949). A summary is given of the development, production and properties of cast tungsten carbide, and sintered or cemented carbide. Their uses in engineering are discussed.

A. Cemented carbides and other hard compounds

(2811) Production and Characteristics of Tungsten Carbides. M. R. Andrew, *J. Phys. Chem., 27,* 270-83 (1923). At the surface of an incandescent filament, heated at 870° C. (1600° F.), $C_{10}H_8$ is decomposed, and its entire C unites with W; the filament is first converted into W_2C and then to WC; both are brittle.

(2812) A Hard Alloy. *English Mechanics, 123,* 75 (1926). An alloy consisting of a fused mixture of W carbides and W is produced in Wetzlar (Germany).

(2813) The Hardness of Inorganic Compounds. E. Friederich, *Fortschr. Chem. 18,* No. 12, 11 (1926). The hardness of tungsten carbide is stated to be 9^+ on Mohs' scale.

(2814) Tungsten Carbides and Their Applications. F. Skaupy, *Z. Elektrochem., 33,* 487-491 (1927). Details are given of the development of the cobalt-cemented tungsten carbide at the Osram Gesellschaft, Berlin.

(2815) Tungsten Carbide - A New Tool Material. S. L. Hoyt, *Trans. Am. Soc. Steel Treating, 14,* 695-718 (1928). The properties and production of cemented carbides is described.

(2816) Metallographic Study of Tungsten Carbide Alloys. J. L. Gregg and C. W. Küttner, *Trans. Am. Inst. Mining Met. Eng., 83,* 581-90 (1929). X-ray and metallographic examination has been made of Thoran, Diamonite, Elmarid, Walramite and Widia; the first four contain W_2C and WC; Widia only WC.

(2817) Present Status of Cemented Tungsten Carbide Tools. Z. Jeffries, *Metals & Alloys, 1,* 222-25 (1929). W carbide tools and dies are made by grinding a mixture of W carbide powder and Co in a ball mill until Co is smeared over the surface of the carbide particles. Mixture is then pressed in shape and sintered.

(2818) The Mechanical and Other Properties of the Hard Metal Widia. C. Agte, *Metallwirtschaft, 9,* 401 (1930). Widia or Carboloy manufactured by Krupp and General Electric Co. Data given for hardness, transverse strength, torsional resistance, heat and electrical conductivities.

(2819) Systems of High-Melting Carbides; Contribution to Problems of Carbon Fusion. C. Agte and H. Alterthum, *Z. tech. Phys., 11,* 182-91 (1930). ZrC, CbC, MoC, Mo_2C, HgC, TaC, WC, W_2C were studied.

(2820) Radiation Characteristics of Tantalum Carbide. K. Becker and H. Ewest, *Z. tech. Phys., 11,* 148-50, 216-20 (1930). TaC wires made by (*1*) extrusion, (2) heating of Ta-filaments in hydrocarbon, (*3*) deposition on gas phase. Practical application of TaC filaments.

(2821) Cemented Tungsten Carbide. G. J. Comstock, *Trans. Am. Soc. Steel Treating, 18,* 993-1008 (1930). The physical properties of cemented W-carbides are high hardness, high heat conductivity, and low coefficient of expansion. Regulation of the grain size in the finished product.

(2822) Hard Metal Carbides and Cemented Tungsten Carbides. S. L. Hoyt, *Trans. Am. Inst. Mining Met. Engrs., 89,* 9-58 (1930). Properties of cemented carbide products and their dependence on their history.

(2823) Cemented Tantalum Carbide. *Metal Progress, 19,* No. 3, 53-55 (1931). Describes the manufacture and properties of "Ramet" consisting of Ta carbides and cemented with Ni. Melting point of TaC is 4400° C. (7900° F.).

(2824) Preparation of Pure High-Melting Carbides, Nitrides, Borides and Their Properties. C. Agte and K. Moers, *Z. anorg. allgem. Chem., 198,* 233, 243-61, 262 (1931). The paper describes: preparation of these and binder according to sinter method; preparation by the method of growth and a few properties; and conductivity measurements at low and high temperatures.

(2825) Preparation of Microsections of Tungsten Carbide. S. L. Hoyt, *Trans. Am. Soc. Steel Treating, 17,* 54-58 (1931). In a discussion of the production of cemented WC, it is explained that the carbide powders are ball-milled for some time, after which the cobalt is added. It is theorized that the carbide grains become coated with the cobalt.

(2826) Cemented Tantalum Carbides. F. C. Kelley, *Gen. Electric Co., Res. Lab., Rept. No. 595,* 1931. Nickel is superior as binder to cobalt, and iron appears to have too great a solubility with tantalum carbide at room temperature.

(2827) Cemented Tungsten Carbides. L. L. Wyman and F. C. Kelley, *Trans. Am. Inst. Mining Met. Engrs., 93,* 208-29 (1931). Authors have the opinion that the binding constituent in cemented W carbide material usually reaches the liquid state during the sintering, at which time it consists of W carbide dissolved in Co.

(2828) Molybdenum-Titanium Carbide Cutting Tools. *Machinery (London), 40,* 365-67 (1932). "Cutanit" is a sintered alloy containing Mo carbide and Ti carbide, but no W; the results of cutting tests are quoted.

(2829) New Developments in Hard Carbide Materials. G. J. Comstock, *Machinery (N. Y.), 38,* 735-7 (1932). Review of some recent developments in hard cemented carbide materials, Ta as binder addition.

(2830) New Alloy Cements for Hard Metal Carbides. C. G. Fink and G. A. Meyerson, *Iron Age, 130,* No. 1, 8-9, 47 (1932). Decrease in brittleness by proper choice of matrix (binder) metal is established. An alloy of 94.75% WC and 5.25% Co in which the cementing material was an alloy of Co, W and C, has a hardness equal to 87.3 Rockwell.

(2831) Cemented Tantalum Carbide Tools. F. C. Kelley, *Trans. Am. Soc. Steel Treating, 19,* 233-46 (1932). A description of the "Ramet" type tungsten-tantalum base cemented carbide is given.

(2832) High Percentage Tungsten Carbide Alloys and Their Technical Application. S. G. Lind, *Tek. Tid., Uppl. C. Kemi Bergvedenskap, 62,* 9 (1932). The manufacture of alloys of cemented W-carbides and Co and their mechanical properties are described.

(2833) Super-Hard Alloys of Sintered Powders. G. A. Meerson, *Vestnik Metalloprom., 12,* No. 2, 60-67, No. 3, 67-73, No. 5, 59-67 (1932); *J. Inst. Metals,*

53, 302 (1933). Description of the production of alloys containing W carbides and Co in U.S.S.R.

(2834) A New Method for Welding the Extra Hard Alloy "Pobedit". G. E. Varshavskii, *Azerbaidzhanskoe Neflyanoe Khozyaistvo, 12*, 24-32 (1932). I. Technology of welding and laboratory investigations; II. Field tests.

(2835) Non-Ferrous Super High-Speed Cutting Alloys. *Machinery (London), 41*, 715-24 (1933). A review of four British-made cutting alloys: "Wimet, Ardaloy, Cutanit, Stellite."

(2836) Carbides in Carbon-Containing Alloys of Tungsten and Molybdenum with Chromium, Manganese, Iron, Cobalt and Nickel. V. Adelskoeld, A. Sundelin and A. Westgren, *Z. anorg. allgem. Chem., 212*, 401-9 (1933). X-ray analysis of C-containing alloys discloses structure and phase changes.

(2837) Dispersoid Chemistry of Hard Metals. K. Becker, *Kolloid-Z., 63*, 373-74 (1933). A review of patent literature of high-melting carbides, covering powder production, milling, composition and structure.

(2838) The Hard Alloy Elvotit. J. Golub, *Vestnik Metalloprom., 13*, No. 8, 65-66 (1933); *Met. Abstr., 1*, 460 (1934). "Elvotit" contains 30% TiC and 70% WC; it is compared with the plain Co-cemented tungsten carbide alloy "Pobedit."

(2839) Pressed Hard Alloys by Precipitation from Salt Solution. V. D. Romanov and V. I. Tretyakov, *Redkie Metal., 2*, No. 4, 32-34 (1933); *Met. Abstr., 1*, 460 (1934). "Pobedit," a W carbide, is mixed with moistened Zn dust, and then with a Co salt solution, whereby a vigorous displacement of Co by Zn occurs.

(2840) Boron Carbide. R. R. Ridgway, *Trans. Am. Electrochem. Soc., 66*, 117-133 (1934). The density, thermal coefficient of expansion, melting point, compressive and breaking strength, and electrical conductivity of B_4C were determined.

(2841) Inception and Development of Hard Metal Carbides and Analysis of Hard Metal Carbide Theory. K. Schröter, *Iron Age, 133*, No. 5, 27-9; No. 8, 21, 61 (1934). It was found that there are certain methods which besides lowering the sintering temperature, also impart to the material the desired tenacity in a successful manner. Relationship of sintering temperature to grain size.

(2842) Replacement of Cobalt by Nickel in Hard Alloys. V. I. Tretyakov and N. D. Titov, *Redkie Metal., 3*, No. 1, 24-27 (1934); *Met. Abstr., 1*, 573 (1934). In the preparation of "Pobedit," a mixture of W carbides and Zn dust is shaken with an ammoniacal solution of Ni salt and the metallic residue is washed out. The sintering is effected in absence of C.

(2843) Investigation of Alloys Prepared by Sintering. N. Zarubin and L. Mol'kov, *Vestnik Metallprom., 14*, No. 7, 59-68 (1934); *Met. Abstr., 2*, 148 (1935). The microstructure of alloys of Co with carbides of Mo, Ta, Ti, prepared by sintering of their powders, has been examined.

(2844) Carbides of Refractory Metals. G. A. Meerson, *Redkie Metal., 4*, No. 4, 6-20 (1935). Experiments with TiC and mixture of WC and TiC. Preparation of TiC via TiO_2 plus C.

(2845) Mode of Action of Etching Reagents for Carbides. R. Mitsche, *Arch. Eisenhüttenwesen, 9*, 311-312 (1935). Widia-type hard metal was used for the investigation.

(2846) Tantalum-Carbide in Cemented Carbide Compositions. L. P. Mol'kov and A. V. Chochlova, *Redkie Metal., 4*, No. 1, 10-16, 24-30 (1935); *Met. Abstr., 2*, 680 (1935). Experimental study of production of TaC-base cemented carbides. Microscopic examination of alloys with Ni and Co sintered in H showed that the solubility of TaC in Co is 6% and the eutectic point 35% TaC. The solubility of TaC in Ni is 20%.

(2847) V. S. Rakowski, *Principles of the Production of Hard Alloys*. Gonti, Moscow, 1935 (in Russian), 96 pp.; *Met. Abstr., 2*, 549 (1935). Tungsten carbide production treated in a practical review.

(2848) Tungsten. W. O. Vanderburg, *U. S. Bureau of Mines Inf. Circ. No. 6821*, 1935. The manufacture of cemented tungsten carbides is included in the discussion.

(2849) Alloys Prepared by Sintering Methods. N. M. Zarubin, *Redkie Metal.*, *4*, No. 6, 18-23 (1935); *Met. Abstr.*, *2*, 682 (1935). Investigation of free C in WC-Co mixtures results in porous microstructure. Free C reduces the hardness and shrinkage, and increases the brittleness.

(2850) Investigation of Alloys Produced According to Sintering Methods. N. M. Zarubin and L. P. Molkov, *Vestnik Metalloprom.*, *15*, No. 7, 93-8; *Met. Abstr.*, *2*, 683 (1935). Metallographical investigation of carbide systems established that the solubility of the carbides in Ni is 25% WC, 12% Mo_2C, 20% TaC; TiC is insoluble.

(2851) Alloys Prepared by Sintering Methods. N. M. Zarubin and M. V. Sitin, *Redkie Metal.*, *4*, No. 4, 21-5 (1935); *Met. Abstr.*, *3*, 659 (1936). Alloys of W-carbide and Fe containing 5-90% WC, and of Mo_2C and Fe containing 2-90% Mo_2C were sintered, at 1450° C. (2640° F.) for 1½ hours. Eutectics found at about 30% of the carbides in either system.

(2852) Properties of Hard Cemented Carbides at Elevated Temperatures. I. S. Brokhin, *Vestnik Metalloprom.*, *16*, No. 14, 63-75, No. 15, 20-25 (1936). Specimens of Pobedit containing 5.3% C, 10-11% Co, 82.4% W, 0.17% Si, bal. Fe were tested at temperatures up to 800° C. (1470° F.).

(2853) Tantalum Carbide, Its Relation to Other Refractory Compounds. P. M. McKenna, *Ind. Eng. Chem., Ind. Ed.*, *28*, 767-772 (1936). The densities, crystalline form, and lattice dimension of Ta- and Cb-carbides were determined; both crystallize in the sodium chloride type.

(2854) Influence of Excess Tungsten on Pobedit and Substitution of Nickel for Cobalt. G. A. Meerson, A. N. Korolkov, M. M. Babich and L. P. Nevskaia, *Legkie Metal.*, *5*, No. 3, 38-46 (1936); *Met. Abstr.*, *4*, 42 (1937). Substitution of Ni for 10% of Co increases the bending strength but further additions reduces it, and the alloys are rendered more porous.

(2855) Metallographic Study of the Action of the Cementing Materials for Cemented Tungsten Carbide. S. Takeda, *Tohoku Imp. Univ. Sci. Rept.*, *25*, Ser. 1, *Honda Anniv. Vol.*, 864-881 (1936). WC-Co and WC-Ni alloys are investigated.

(2856) Sintering of Hard Metal Alloys. W. D. Jones, *Metallurgist*, *11*, 171-75 (1938). Critical review of paper by O. Meyer and W. Eilender, *Arch. Eisenhüttenw.*, *11*, 545-62 (1938).

(2857) Physical Tests on Hard Alloys. A. I. Korotkoruchko and B. G. Livshits, *Zavodskaya Lab.*, *7*, 202-204 (1938). Physical and mechanical properties and the magnetic saturation of alloy of W-carbide with 2.5-15% Ni were studied.

(2858) Tantalum Carbide. P. M. McKenna, *Scientific Monthly*, *46*, 566-8 (1938). Described as the substance with the highest known melting point.

(2859) Tantalum Carbide Tool Composition. P. M. McKenna, *Trans. Am. Inst. Mining Met. Engrs.*, *128*, 90-103 (1938). Properties of hard tool materials produced by powder metallurgical processes from hard carbides in matrixes of Fe, Ni, Co, etc. Thermal conductivity tests, microscopic examinations.

(2860) Sintering of Hard Metal Alloys. O. Meyer and W. Eilender, *Arch. Eisenhüttenw.*, *11*, 545-562 (1938). Influence of the manner of production on the qualities of W-carbides. Sintered alloys on a nitride basis. The necessary qualities of the powders for the production of hard metal.

(2861) The Modern Method of Manufacturing Aluminum Powder. H. Meyersberg, *Aluminum Non-Ferrous Rev.*, *3*, 299-302, 397-399; *4*, 5-8 (1938). New process: nitrogen used for protection with 1-3% oxygen to produce oxide film. Flatting done in drum containing steel balls which are dropped on material during rotation.

(2862) Cemented Tungsten Carbide Alloys. W. P. Sykes, *Trans. Am. Inst. Mining Met. Engrs.*, *128*, 76-89 (1938). WC-Co system is investigated, and microstructures are illustrated. Steps in the preparation of the alloys are discussed.

(2863) Quest For Hard Materials. F. J. Tone, *Ind. Eng. Chem., Anal. Ed.*, *30*, No. 2, 232-42 (1938). Microstructure of boron carbide, silicon carbide, silicon boride and their joint fusion products; Ta carbide dissolved in B carbide,,

Zr carbide dissolved in B carbide; V-B-C fusion product containing free graphite.

(2864) New Methods in Hard Metal Manufacture. *Berg- u. Hüttenmänn. Monatsh., montan. Hochschule, Leoben, 87,* No. 10, 185-6 (1939). Method of making material for cutting tools by adding nickel powder to finely ground Ta-carbide.

(2865) Occurrences During Wear in Sliding Dry Friction. K. Dies, *Z. Ver. deut. Ing., 83,* 307-14 (1939). Experiments on the cutting performance of cemented carbides indicate that oxide films prevent welding of the hard metal to the work.

(2866) New Intermetallic Compound. P. M. McKenna, *Ind. Eng. Chem., News Ed., 17,* No. 14, 476 (1939). Discovery of a new intermetallic compound corresponding to the formula $W_2Ti_2C_4$, obtained by heating W, Ti, C in pure graphite crucibles in a bath of Ni at 1090° C. (2000° F.).

(2867) Hard Intermetallic Compounds for New Metal Cutting Tools. P. M. McKenna, *Metal Progress, 36,* No. 2, 152-55 (1939). Carburized tungsten-titanium results in a compound $WTiC_2$; the process is described in detail, whereby this compound is used in the manufacture of cutting tool material.

(2868) Multiple Carbides. R. Mitsche, *Berg- u. Hüttenmänn. Monatsh. montan. Hochschule, Leoben, 87,* 185-186 (1939). A description is given of McKenna's menstruum process.

(2869) Determination of Cobalt and Nickel in Green and Sintered Compacts with Tungsten Carbide Base. V. G. Shcherbakov, *Zavodskaya Lab., 8,* 389-90 (1939). Two methods based on the destruction of the carbide are described.

(2870) A New Cutting Alloy (Kennametal). *Machinery (London), 55,* No. 1422, 397-398 (1940). Alloy is prepared by sintering $WTiC_2$ with a cobalt binder in vacuum furnaces. Suitable for machining non-ferrous metals.

(2871) Extrusion Process for Cemented Carbides. *Metals & Alloys, 11,* No. 1, MA-10 (1940). Carboloy cemented carbide now can be produced in the form of tubing, spirals and round and shaped bars by means of an extrusion process.

(2872) The Development of Hard Metals. E. Ammann, *Z. tech. Physik, 21,* No. 12, 332-35 (1940). The properties of the sintered hard metals are discussed. Tests with a gravel blower for wear resistance are referred to.

(2873) Cutting Performance of Hard Metals. C. Ballhausen, *Z. Metallkunde, 32,* 326 (1940). The cutting performance of various hard metal compositions is discussed, and experimental work is described.

(2874) Corrosion Resistance of Hard Metal Alloys. W. Dawihl, *Chem. Fabrik, 13,* No. 8, 133-5 (1940). Alloys containing WC or WC-TiC may resist acid till 600° C. (1110° F.). Hard metal alloys with auxiliary metal are stable against sulfuric acid or hydrofluoric acid. At boiling temperatures the auxiliary metal will be dissolved.

(2875) Principles of Using Hard Metal Alloys. W. Dawihl, *Maschinenbau-Betrieb, 19,* No. 12, 521-4 (1940). The structure of the alloys consists of a skeleton of W-carbide particles with Co embedded in the gaps. Hard metal alloys containing Ti-carbides have little affinity to welding steel.

(2876) Properties of Cemented Carbide Compositions and Their Relation to the Wear Resistance. W. Dawihl, *Z. Metallkunde, 32,* No. 9, 320-25 (1940). Experimental study of the difference in performance between cemented carbides with and without TiC in the cutting of steel, cast Fe and brass.

(2877) Influence of Diffusion and Alloy Formation on Resistance to Wear of Cemented Carbide Compositions. W. Dawihl, *Z. tech. Phys., 21,* No. 2, 44-48 (1940). Wear of cemented carbides due to dry friction against iron and steel is a function of diffusion and alloy formation between the carbide composition and the work material.

(2878) Investigations of the Processes in the Wear of Cemented Carbide Material. W. Dawihl, *Z. tech. Phys., 21,* No. 12, 336-345 (1940). Experimental study of wear resistance of cemented carbide compositions.

(2879) Tungsten Carbide-Cobalt Alloys. G. A. Meerson and V. I. Shabalin. *Tsvetnye Metal., 3,* 77-89 (1940) (in Russian); *Metal Ind. (London), 59,* No. 4 50-2 (1941). Sintering of WC-Co mixtures.

(2880) Investigation of the Behavior of Ti-Carbide in Sintered Hard Alloy. G. A. Meerson, G. L. Zverev and B. E. Osinovskaya, *J. Applied Chem. (U. S. S. R.), 13,* No. 1, 66-75 (1940) (in Russian); *Metal Ind. (London), 59,* 306-8 (1941). An analysis of the functions and controls of TiC in multicarbide systems and cemented carbide compositions.

(2881) Hard Alloy "Reniks-6." N. I. Orlov, *Tsvetnye Met., 3,* No. 5/6, 145-150 (1940); *Met. Abstr., 9,* 101 (1942). Description of the development of W carbide alloy with 6% Ni. Cutting tests on cast iron of 183-194 Brinell hardness showed that the alloy compares very favorably with W-Co steels.

(2882) Potentiometric Determination of Cobalt in Cemented Carbide Composition. V. G. Shscherbakov and T. S. Kholcheva, *Zavodskaya Lab., 9,* 827-30 (1940). A new analytical method is described.

(2883) The Phenomenom of Friction on Hard Metals. C. Ballhausen, *Werkstatts-technik, Werksleiter, 35,* 225-27 (1941). An arrangement for tests on a lathe for the determination of the value of friction during turning with hard metals is described.

(2884) Hard Metal Alloys. W. Dawihl, *Chem. Ztg., 65,* No. 31/32, 146-8 (1941). Cemented carbide alloys, their structure and properties are discussed.

(2885) Sintered Carbides — Their Resistance to Corrosion. W. Dawihl, *S. African Elec. Rev. and Engr., 32,* No. 273, 17, 19 (1941). Data of weight losses are tabulated.

(2886) Hard Metal Alloys. Ya. M. Lipkes and G. A. Meerson, *Metal Ind. (London), 59,* No. 19, 290-93 (1941). Results of investigation with reference to WC-TiC-Co mixtures.

(2887) Structure and Cutting Efficiency of Tungsten Carbides. H. Ogawa, *Tetsu-to-Hagane, 27,* No. 6, 405-410 (1941); *Met. Abstr., 9,* 15 (1942). The hardness, porosity and microstructure of an hard alloy with 6% Co was studied; the grain size should be small, as it has important influence on their resistance to impact and to wear.

(2888) Relation between Strength of Weld and Wear. W. Dawihl and W. Rix, *Z. Metallkunde, 34,* No. 7, 156-58 (1942). Testing of the weld phenomenon between steel and hard metal alloys confirms the superiority of TiC alloys during the turning of steel, on account of their tendency to form inferior welding.

(2889) Investigation into Conditions of Preparation of Cemented Tungsten Carbide. J. N. Greenwood and R. W. K. Honeycombe, *Proc. Australasian Inst. Mining & Met., 128,* 259-70 (1942). 9% Co-W carbide developed for use as cutting tip. Effect of certain variables on properties of alloy.

(2890) Production of Hard Metal Alloys and Its Use for Drawing Dies. J. Hinnüber, *Stahl u. Eisen, 62,* No. 52, 1083-1091 (1942). Contains values for the modulus of elasticity of cemented tungsten carbide containing different percentages of cobalt.

(2891) Metallic Carbides and Their Sintered Products. R. W. K. Honeycombe, *Australasian Engr., 42,* No. 313, 11-13, 25-29 (1942). Preparation of metallic carbides and manufacture of their sintered, cemented products are described in detail. Cold and hot pressing, pre- and final sintering and bonding described.

(2892) Preparation and Properties of Cemented Carbides. R. W. K. Honeycombe, *Proc. Australasian Inst. Mining & Met., 128,* 227-57 (1942). Hard carbides of Cr, Zr, Nb, Mo, Hf, Ta and W investigated. Production summary, control of properties given, also some uses.

(2893) Effect of Particle Size on the Microstructure of Cemented Tungsten Carbide. M. F. Rogers, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 16, pp. 182-185. Electron microscopic pictures of particles and optical-microscopic pictures of finished cemented carbide structures are shown.

(2894) Dispersoid-Chemical and Related Points of View in Sintered Hard Metals. F. Skaupy, *Kolloid-Z., 98,* 92-95 (1942); *Chem. Zentr., 113,* No. 1, 3140 (1942). Compositions, production and properties of various products containing one carbide metal and one binder metal are discussed.

(2895) Hard Cutting Tools and Their Shaping. *Le Genie Civil, 120,* No. 5, 49 (1943). Choice and proportions of constituents for cutting tips vary according to qualities of endurance, hardness, and resistance to wear and tear.

(2896) The Structure of Hard Metal Alloys. W. Dawihl and J. Hinnüber, *Kolloid-Z., 104,* No. 2/3, 233-36 (1943). Hardness and excellent wearing qualities of hard metal alloys explained on basis of experiments performed.

(2897) Determination of Structure and Composition of the Double Carbides in the System W-Co-C by Means of Investigations on the Relative Density of Debye Lines. E. N. Kislyakova, *J. Phys. Chem. (U.S.S.R.), 17,* 108-14 (1943). X-ray investigation of various W-Co-C alloys.

(2898) Tungsten Carbide. R.C. Lister and J.C. Richards, *Ind. Australian & Mining Standards, 98,* No. 2509, 50-53 (1943). Effect of TiC additions to normal WC-Co alloy.

(2899) Hard Metal Alloys With Heat-Resistant Carbides as a Basis. M. Oswald, *Chim. et ind., 49,* 8-16 (1943); *Chem. Zentr.,* I, 2236 (1943). Review of properties, lattice structure and grain structure of W, Ti, Ta-carbides and mixed carbides. Effect of Co content on structure and properties.

(2900) Carbides. A. A. Schwartz, *Steel, 113,* No. 16, 84-6 (1943). Characteristics of carbides discussed.

(2901) Carbides of Hard Alloys. Ya. S. Umanskii, *Ann. secteur anal. phys. chim., Inst. chim. gen., U.S.S.R., 16,* No. 1, 127-148 (1943); *C. A., 39,* 4310 (1945). C, H, and N probably combine with transition elements by giving up some of their electrons to the vacant position of the *d* level of the elements, and thus themselves go into the metallic state.

(2902) Large Carbide Parts Formed by New Hot-Pressing Method. *Ind. Heating, 11,* No. 12, 2024-26 (1944); *Western Metals, 3,* No. 2, 54 (1944). Carboloy process of pressing, semi-sintering and sintering simultaneously large carbide parts.

(2903) Hot-Pressing and Sintering of Large Carbide Powder Parts. *Iron Age, 153,* No. 23, 71 (1944). Ability to produce cemented carbide parts too large to be sintered in available furnaces – as well as special thin-walled parts – has been made possible by the development of hot-pressing.

(2904) Large Cemented Carbide Parts. *Steel, 114,* No. 22, 99 (1944); also *Metal Progress, 45,* No. 4, 681-2 (1944). Cemented carbide parts too large to be sintered in available furnaces, as well as special, thin walled parts that tend to go out of round when pressed and sintered in regular way, are now being made by hot-pressing by Carboloy Co.

(2905) Gebruder Böhler A. G., Büderich: Quality Alloy Steels, Tool Steels and Forgings. H.M. Brightman, G.J. Comstock, J.D. Dickerson, T.G. Foulkes, R.A. Gezelius, S. F. Grover, G. Meikle, C. F. Park and H. C. Smith. C. I. O. S. Rept. No. XXV-14 (1945). A cursory description of the carbide-making process, with some interesting details on the war-time carbide policy in Germany.

(2906) German Production of Sintered Boron Carbide. *Ind. Diamond Rev., 6,* 413 (1946). From report by M. Fischmann, U. S. A. (Ordn.) C.I.O.S. Target No. 21/202, Metallurgy, H.M. Stationery Office, London, 1946.

(2907) Metallic Carbides and Hard Alloys. W. G. Cass, *Ind. Diamond Rev., 6,* 376-77 (1946). French patents of sintered carbides reviewed. W-carbide cemented with a Co-7% Fe alloy matrix. Double carbides of Zr and W found superior to Zr-carbide alone.

(2908) Certain Aspects of German Hard Cemented Carbide Industry. G. J. Comstock, U.S. Dept. Comm. PB. 28339/1945, 48 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 7, 505 (1946). The hot-pressing of carbide powders was brought to a high state of perfection. Establishment of quotas of raw material; limitation of grades of tips for cutting tools, and the use of standard grades.

(2909) Tungsten Carbide. Fried. Krupp A.G., Essen. B.I.O.S. Final Rept. No. 820. Items Nos. 21 and 22, 43 pp. (1946); *Met. Powd. Rept., 1,* No. 4, 56-57 (1946). A report on the production of WC and allied powders and hard metals therefrom in Germany from 1939 on. Notes on the Krupp Widia plant.

(2910) Research Reports on Hard Metal Research. Fried. Krupp A. G., Essen, F. D. Rept. No. 258/46 (1946).
Part 1. Tungsten Carbide. This report, dated January, 1940, discusses grinding and mixing; pressing; the importance of residual oxygen in the tungsten powder; carburizing; sintering of WC-Co, W_2C-Co, WC-TiC; apparent porosity (due to preparation of the specimen); determination of the different constituents in the different types of hard metal; comparison of structures with behavior in use, *e.g.*, susceptibility to oxidation in cutting steel, etc.; need for producing pure TiC and pure VC before developing WC-free tools.
Part 2. This folder also contains a quarterly report (October-December 1940) on the work of the department; some details on the effect of grinding on the activation of cobalt powder, removal of free graphite in TiC by treatment with ZnO at temperatures up to 2000° C., and the properties of TiC plus 10% TiN (Rockwell A-92, but fairly brittle and difficult to braze).
Part 3. In a 34-page report on hard metals, dated August, 1939, by R. Flüshöh, U. Schmidt and W. Dawihl, the metallographic studies are covered with full details of etching reagents, etc.
Part 4. A 5-page report on uranium and several of its compounds gives the phases in sintered U_3O_8, UO_3, UO_2, UC (saturated and with carbon deficiency), and U metal. (Report dated September, 1942).
Part 5. Magnetic saturation measurements on WC-Ni showed that minimum magnetization occurred at 1350-1400° C. (2460-2550° F.) compared with 1000° C. (1830° F.) for WC-Co. (Report dated September, 1942).
Part 6. Boron carbide prepared by ball-milling is much inferior to diamond for polishing purposes as it has a tearing rather than a cutting action, but a satisfactory product appears to have been obtained by grinding between rollers. (Report dated July, 1942).
Part 7. A 3-page report deals with the manufacture of saturated uranium carbide (UC_2) from U, UC, UO_2 and C, and its storage in CO_2 (diagram). The material is claimed to have only theoretical significance because of its low specific gravity of 11.3. (Report dated October, 1942).
Part 8. TiC-VC hard metal must be hot-pressed and not cold-pressed and sintered because of differences in crystal formation by the two methods (report dated Jan., 1940). A full metallographic study is given in two reports dated November and December, 1942.

(2911) New Cemented Carbide Composition of Increased Hardness and Toughness. M. I. Genzelovich, *Automobil'naya Prom.*, No. 9-10, 20-21 (1946); *C. A., 41*, No. 9, 2682 (1947). Data on two new WC-Co compositions and their hot pressing by a new process are given.

(2912) Metallurgical Examination of Tungsten Carbide Powder and Compacts. L. H. Grenell, U. S. Dept. Comm. PB. 22005/1945, 6 pp.; *Bibl. Scient. & Ind. Rept., 1*, No. 24, 1490 (1946). W carbide powder and compacts, produced in Germany, are analyzed and compared with U. S. material.

(2913) Statements at Meeting of Tungsten Free Hard Metal Committee in Essen. R. Kieffer, U. S. Dept. Comm. PB. 6785, 3 pp.; *Bibl. Scient. & Ind. Rept., 1*, No. 20, 1183 (1946). A summary of remarks on the examination of various carbide alloys including substitutes for W carbides; other economical alloys and trials with B_4C and CbC.

(2914) Hardness and Wear Resistance. M. Littmann, *Engineering (London), 159*, 502-03 (1946). The hardness of cemented carbides is investigated.

(2915) German Versus American Cemented Carbides. P. M. McKenna, *Iron Age, 157*, No. 6, 64-8 (1946). Comparative data on microstructure and physical properties of German and American cemented carbides. Interpretation of properties reveals that no progress was made in Germany during 10 years in production of cemented carbide tool metal.

(2916) Composite Carbides in Steel Cutting Cemented Carbides. A. G. Metcalfe, *Metal Treatment, 13*, 127-40 (1946). The influence of frictional effects on the cutting properties of various hard metal compositions is discussed. The role of TiC in helping to form a tenacious oxide coating on a tool tip which enhances the tool life is shown.

(2917) Report on the Manufacture of Cemented Hard Carbides (Hard Metals) Using the Cold Pressing Method. A. Niedzwiedski, F. D. Rept. No. 2664/46

(formerly H.E.C. 12577), 1946. Recommends compacting pressures of about 6 tsi.

(2918) Improvements in the Sintering Technique in Hard Metal Production. G. Ritzau, F.D. Rept. No. 1179/46 (formerly H. E. C. 10012), 1946. Sintered materials on iron-alumina basis included in discussion. Magnetic analysis of hard metals.

(2919) Improvements in Sintering Technique in Hard Metal Production. G. Ritzau, U.S. Dept. Comm. PB 25334 (1946). Ball mills with hard metal lining are used to prevent iron from being absorbed during 200 hrs. of grinding. Presintering, to strengthen the hard-metal pressing, can be avoided by mixing the powder with polyvinyl solution; the pressing must then follow very quickly.

(2920) Carbides for High Temperature Applications. *Materials & Methods, 26,* No. 6. 85 (1947). The new titanium carbide base (Kennametal K-138) belongs to the "ceramal" group; it has excellent properties at elevated temperatures, and looks promising for gas turbine buckets and furnace parts.

(2921) Promising Metal. *Steel, 121,* No. 26, 45 (1947). Germans developed during the war a tungsten-free hard metal for tooling, using V and Ti with Fe as binder; Ti- and V-carbide made by carburizing oxide or sesquioxide in H atmosphere.

(2922) Sintering Mechanism of Mixtures of Carbides and Binder. U.S. Dept. Comm., PB. 70489, Rept. 131-132 (1947). Report based on visit to Krupp Widia Werke, Essen. Sintering mechanism elucidated by correlating extent of recrystallization with changes in the magnetic saturation.

(2923) Determination of Solubility Limit for Cobalt in Tungsten Carbide. U. S. Dept. Comm., PB. 70489, Rept. 133 (1947). Report on Krupp Widia Werke, Essen. Compositions with various low cobalt contents sintered at 1200-1500° C. (2200-2730° F.) and magnetic saturation values are measured after cooling. Solubility limits are obtained by extrapolation of saturation *vs.* cobalt concentration curves.

(2924) High Temperature Refractory Material with Low Specific Gravity. J. Bingel, *Arch. Metallkunde, 1,* No. 7/8, 309-310 (1947). Author was working in 1938 on gas-turbine blades using hot-pressing on compositions of 84% SiC, 5% TiC, 2% W, 6% Co, 3% Cr; and 88% SiC, 2% TiC, 10% Fe.

(2925) Cemented Tungsten Carbides. S. H. Brierley, *Metallurgia, 35,* No. 209, 253 (1947). Brief outline of processes involved. Description of double-sintering and single-sintering methods.

(2926) Manipulation and Sintering of Hard Metals. H. Burden, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 78-83; *Met. Powd. Rept., 1,* No. 11, 168 (1947). Compacting pressure has no influence on the properties of sintered production lots, in contrast to earlier views; it can vary over wide range (0.25-40 tsi); powder can vary from 0.2 to 8 microns.

(2927) Production Engineering Research in Germany. W. A. Carter, B.I.O.S. Final Rept. No. 1519 (1947). Some sparse data on carbide and ceramic cutting tools are included.

(2928) Report on German Carbide Industry. H. Crump, U. S. Dept. Comm. PB. 1265r/1946, 245 pp.; *Bibl. Scient. & Ind. Rept., 5,* No. 3, 208 (1947). History of the production of hard metal tool tips by Krupp; application of Widia; introduction of the titanium bearing Widia. Charts showing presintering and sintering temperatures of ten standard grades.

(2929) Zone Formation in Hard Metal. W. Dawihl and Studienges. Hartmetall, F. D. Rept. No. 3930/47 (1947). The entrapment by a liquid Co-WC layer of O and N mainly from the Ti carbide component. O in Co is also considered to produce local hardness variations, according to whether it is randomly distributed in the lattice, or is present as Co_3O_4. Investigations made and reported on in 1942-43.

(2930) Widia Hard Metal and Its Application. Fried. Krupp A.G., Essen. F.D. Rept. No. 4170/47 (1947). A series of data sheets for Widia cutting tools, dated 1937-45.

(2931) Tungsten Carbide Dies, with Special Reference to Re-Pressing. Fried. Krupp A. G., Widia Fabrik, Berlin. F.D. Rept. No. 1121/47 (1947). A number of Krupp's data sheets on their wire-drawing dies, dated 1944-45. See also B.I.O.S. Report No. 1214, p. 48.

(2932) Tungsten Carbide Research in Germany. W. Ivory, B.I.O.S. Final Rept. No. 925, 50 pp.; *Met. Powd. Rept., 2,* No. 4, 61-63 (1947). Detailed report on interview of W. Dawihl of the Osram A. G. and on internal communications by Osram and publications by Dawihl.

(2933) Cast Tungsten Carbide and Production of Tungsten-Free Hard Metal. W. Ivory, B.I.O.S. Final Rept. No. 1076, 70 pp.; *Met. Powd. Rept., 1,* No. 10, 150 (1947). (*1*) Sintered titanium carbide-vanadium-carbide tools; (*2*) casting W carbide as an alternative to Krupp's fully patented sintering method; (*3*) uranium carbide as substitute for W-carbide; trials were made with U_3O_8 mixed with lampblack, reduced in graphite crucibles, carburized in H atmosphere.

(2934) Microstructure of Sintered Carbides, In Particular of Tungsten Carbide - Titanium Carbide - Cobalt Alloys. R. Kieffer, *Metallforschung, 2,* No. 7/8, 236-238; *Met. Powder Rept., 2,* No. 7, 111 (1947). Several photomicrographs of double carbides show the exceptionally large grain growth which results from prolonged sintering.

(2935) Structure of Sintered Hard Metals, Particularly Tungsten Carbide - Titanium Carbide-Cobalt Alloys. R. Kieffer, *Powd. Met. Bull., 2,* No. 5, 104-111 (1947). A new metallographic method developed for investigation of cemented carbides, and in particular tungsten carbide-titanium carbide-cobalt materials. (Article is a translation of paper previously published in *Z. Metallkunde, 36,* No. 9 (1944), an issue which was, during the war, destroyed by fire).

(2936) Investigations of Sintered Hard Metals. H. Krainer and K. Konopicky *Berg u. Hüttenmänn. Monatsh., Montan Hochschule Leoben, 92,* No. 10/11, 166-78 (1947). European sintered hard metals contain WC with 5-13% Co and sometimes 5-25% TiC. Fine structure of W_2C which reduces the quality can be determined by x-ray examination. TiC, made of TiO_2 and TC, whose content of bound C can be determined by the measurement of the lattice constant. The reaction process is independent of the temperature.

(2937) Sintering of Cobalt Binder. E. C. Mantle, *Metal Treatment, 14,* 141-148 (1947). Author measured density and hardness of tungsten carbon-cobalt compacts containing 4.5 - 35% Co sintered between 1250-1450° C. (2280-2640°F.). Maximum physical properties for each Co content are obtained at optimum sintering temperature. He points out that these results are not consistent either with those of Takeda or of Dawihl and Hinnüber.

(2938) Improvement in Production of Sintered Carbides. A. D. McQuillan, C.S.M. Duggan and M. K. Petch, F.D. Docum. No. 1179/46, 20 pp.; *Met. Powd. Rept., 1,* No. 10, 155 (1947). W carbide was made at Siemens & Halske, A. G. at 1400° C. (2550° F.), ground for 200 hours in ball mills. The presintering at 900° C. (1650° F.) had been replaced by addition to the WC-Co mixture an aqueous solution of polyvinyl alcohol; moist powder must be pressed immediately.

(2939) Mutual Solid Solubility of Tungsten Carbide and Titanium Carbide. A. G. Metcalfe, *J. Inst. Metals, 73,* Pt. 10, 591-608 (1947). Results of x-ray investigation of structure is solid solubility of Ti-carbide in W-carbide.

(2940) Low *vs.* High Pressure in Making Cemented Carbide Tools. A. Niedzwiedski, *Metal Progress, 52,* No. 1, 104 (1947). At Starachowice in U.S.S.R. 22½-ton presses and dies 6 in. long and 1-1½ in. wide are used. Pressure in die was 5600 psi. Pressing at high pressure was done dry in 60-ton press. Dies were 4½ in. long and 1-3/8 in. wide.

(2941) Titanium Carbide and Tungsten Carbide. H. Nowotny and G. Glenk, *Metallforschung, 2,* No. 7/8, 265-269 (1947). Solubilities determined as 70% WC in TiC and 5-10% TiC in WC.

(2942) X-Ray Investigation of Carbide Systems. H. Nowotny and R. Kieffer, *Metallforschung, 2,* No. 7/8, 257-265 (1947). Authors determined the lattice constants of TiC, ZrC, VC, CbC, TaC, WC, Mo_2C, compared with known data; the differences are attributed to varying impurity contents.

(2943) Investigations as Regards Efficiency and Use of Metal Carbide Tools. H. Opitz, F.D. Rept. No. 4109/47 (formerly H.E.C. 13684), 1947. A tentative research program drawn up for the Mechanical Engineering Department of the Technische Hochschule, Aachen, in 1946.

(2944) German Methods of Forging and Machining H.E. & A.P. Shell. F.S. Poulton and A. George, B.I.O.S. Final Rept. No. 890 (1947). Describes very briefly the manufacture of tungsten carbide balls at Krupp's.

(2945) Sintering of Tungsten Carbides with Cobalt Binder. E. J. Sandford, *Metal Treatment, 14*, 239-241 (1947). In correspondence on E. C. Mantle's paper Sandford modifies the specific volume/density diagram by using the more recent density figures of Sandford and Trent.

(2946) Production of Cemented Tungsten Carbides. E. J. Sandford and E. Ineson, *Metallurgia, 35*, No. 210, 298-300 (1947). Correspondents from two firms engaged in manufacture of W carbides criticize S. H. Brierley's paper in March issue.

(2947) Physical Metallurgy of Sintered Carbides. E. J. Sandford and E. M. Trent, *Symposium on Powder Metallurgy*. The Iron & Steel Inst. Spec. Rept. No. 38, London, 1947, 84-91; *Met. Powd. Rept., 1*, No. 11, 170 (1947). With Co contents of 3-25% the sintering temperature varies from 1500 to 1350° C. (2730 to 2460° F.), *i.e.*, above the WC-Co eutectic. Shrinkage occurs during sintering, proceeding irregularly as temperature rises above 1150° C. (2100° F.).

(2948) Phönixit: Hard Metal for Cutting Tools. Schoeller-Bleckmann A.G., Berlin. F.D. Rept. No. 5419/47 (1947). Three catalogs of Phönixit tool tips with price lists, dated 1940. Material consists mainly of tungsten carbide with the addition of carbides of molybdenum, thorium and other rare metals.

(2949) Plastic-Bonded Hard Metals. Studiengesellschaft Hartmetall. F.D. Rept. No. 3721/47 (1947). This report of 1932 suggests the use of plastic binders for hard metal carbides in certain types of tools.

(2950) Molybdenum and Titanium Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3722/47 (1947). Properties and analysis of Mo_2C-TiC, bonded with Ni and Cr, are given in report of 1932. A typical analysis is 39.3% Mo, 34.5% Ti, 12.6% Ni, 1.8% Cr, 9.7% C.

(2951) Alternative to Widia. Studiengesellschaft Hartmetall. F.D. Rept. No. 3724/47 (1947). In this report, dating back to 1932, several substitutes for Widia are suggested: tungsten boride plus 10-20% titanium; mainly titanium carbide; tungsten carbide plus zirconium carbide.

(2952) Titanium Boride. Studiengesellschaft Hartmetall. F.D. Rept. No. 3727/47 (1947). Successful demonstration of nickel-cemented titanium boride manufacture by wet ball milling for 15-20 hrs. is given in report of 1932.

(2953) Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3729/47 (1947). Superior cutting performance of vacuum-sintered as compared with ordinary tungsten carbide is discussed in report dating from 1933.

(2954) Elimination of Presintering in Cemented Carbide Manufacture. Studiengesellschaft Hartmetall. F.D. Rept. No. 3740/47 (1947). According to this report of 1936, presintering of hard metal was made unnecessary by using 0.5% of a 7% or 12.5% solution of glyptal resin in acetone.

(2955) Hard Metal. Studiengesellschaft Hartmetall. F.D. Rept. No. 3742/47 (1947). A first report of 1934 states that cobalt oxide gives a better cobalt distribution in the final hard metal, reduction taking place during presintering. A second report of 1936 states that cobalt can be replaced with 4% Fe and 1% Ni, for at least comparable performance.

(2956) Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3747/47 (1947). According to this report of 1936, tungsten carbide begins to decarburize in a dry hydrogen atmosphere at 1100° C. (2010° F.) [in moist H_2 at 900° C. (1650° F.)], leading to complete decarburization at 1450° C. (2640° F.) and 1350° C. (2460° F.), respectively. Equilibrium can be established by adding 1.8% by vol. of methane at 1100° C. (2010° F.), increasing to 8.2% at 1450° C. (2640° F.). The suggestion was made that acetylene mixtures should also be investigated.

(2957) Hard Metals. Studiengesellschaft Hartmetall. F.D. Rept. No. 3750/47 (1947). Experimental tips produced in 1935-36 of titanium carbide bonded with 15% tungsten or chromium gave practically the same results as WC-TiC hard metal. They were too brittle for works' use, but would compare favorably with WC-TiC as regards price of raw material, resistance to acid corrosion, and output of tips per unit weight of carbide. Similar results were obtained with TiC plus 10% Mo_2C. TiC with 10% or 20% W and up to 2% Fe would be permissible for cutting steel, but not for cast iron. Additions of Cr to TiC-W were not successful.

(2958) Tantalum Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3765/47 (1947). Tantalum carbide was prepared, pressed with acetone-camphor and presintered at 1600° C. (2910° F.) for 15 min. It was very difficult to work. Final sintering conditions were not specified in this report of 1937.

(2959) Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3766/47 (1947). Compositions of carbides made by Krupp and Osram in 1937.

(2960) Sintered Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3783/47 (1947). Short-time tests in 1938 with 70/15/15 WC/TiC/TaC gave better results than with Co-bonded hard metal. The sintering temperature had to be about 1700° C. (3090° F.).

(2961) Sintered Tungsten Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3784/47 (1947). According to this report of 1938, the density of cobalt-free WC, vacuum-sintered at 1900-2000° C. (3450-3630° F.) for one hour, is comparable with that of WC-Co.

(2962) Cemented Carbides Without Presintering. Studiengesellschaft Hartmetall. F. D. Rept. No. 3786/47 (1947). This report of 1938 demonstrates that presintering can be eliminated by moistening the hard metal mixture with 4% by weight of a 3% NaOH solution and drying at 200° C. (392° F.) in air. The pressings could be shaped without difficulty.

(2963) Hard Metal Research. Studiengesellschaft Hartmetall. F.D. Rept. No. 3787/47 (1947). Following a meeting of the Deutsche Gesellschaft für Metallkunde in 1938 (abstracts of papers included), a number of suggestions were made for the hard metal research program; hot hammering of hard metals, determination of the strength of sintered cobalt as a function of grain size, determination of the tensile strength of hard metal bars.

(2964) Carbide Skeletons. Studiengesellschaft Hartmetall. F.D. Rept. No. 3789/47 (1947). This report, dating from 1938, discusses experiments wherein WC-Co tips were leached with boiling dilute HCl for periods up to 377 hours, giving coherent WC skeletons. Specimens sintered as low as 900° C. (1650° F.) give similar results.

(2965) Cobalt Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3790/47 (1947). According to this report of 1938, carbon diffuses very slowly into cobalt at 1000° C. (1830° F.), but very rapidly in the presence of a liquid phase above 1300° C. (2370° F.), the Co-C eutectic temperature. Carbide tips sintered in carbon packings, therefore, take up additional carbon. The effect, if any, of iron on this reaction was to be investigated.

(2966) The Role of Cobalt in Cemented Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3791/47 (1947). According to this report of 1938, zoning in WC-TiC-Co occurs with more than 0.15% C. Up to this amount of carbon is desirable for uniform formation of the Co-C eutectic, with which zoning does not take place. Ball-milled (150 hones) and non-ball-milled cobalt have equal grain size at 380° C. (716° F.) which remains constant up to 800° C. (1470° F.), with grain growth up to 1400° C. (2550° F.). This grain growth is retarded by the presence of carbon.

(2967) Cemented Carbide Produced by Vacuum Sintering. Studiengesellschaft Hartmetall. F.D. Rept. No. 3792/47 (1947). The differences arising from vacuum sintering and sintering with carbon absorption are discussed in this report, dating from 1938. Porosity, grain growth, and decomposition of the WC are attributed to the C absorption. This was confirmed by tests on WC-Co deficient in C when blistering was found to occur at lower sintering temperatures due to excess of C in the WC. Neither H nor N was found to assist in

take-up of C. Resintering in vacuum did not reduce the porosity. Deficiencies in C impede grain growth of the WC crystals through formation of a δ phase (presumably the η phase otherwise) corresponding to Co_2W_2C. This phase, being non-porous, causes blistering to start only at higher temperatures.

(2968) Carbides for Cutting Tools. Studiengesellschaft Hartmetall. F.D. Rept. No. 3795/47 (1947). According to this report of 1938, WC-Co is superior to WC-TiC-Co for cutting grey cast iron at normal speeds, but inferior at very high speeds at which the lives of both tools are greatly reduced. Improvements were obtained with WC-Co containing 4% TiC and small amounts of Mo_2C and VC.

(2969) Carbides for Cutting Tools. Studiengesellschaft Hartmetall. F.D. Rept. No. 3796/47 (1947). WC-Co was found to be the best hard metal for cutting armatures reinforced with aluminum, according to this report dating from 1938.

(2970) Carbide Tools. Studiengesellschaft Hartmetall. F.D. Rept. No. 3798/47 (1947). In this report of 1937, it is shown that WC-TiC tools can be made with TiC containing as little as 15% C. Free TiO prevents normal sintering, but TiO-TiC solid solutions do not.

(2971) Sintering of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3801/47 (1947). This report of 1938 shows that while WC at high temperatures takes up carbon via the cobalt, and cannot be decarburized under any conditions of atmosphere or packing, WC-TiC is decarburized with simultaneous nitrogen absorption, possibly via an oxygen take-up. The effect is less marked with a carbon packing than with an alumina packing. WC could be decarburized with an alumina packing, both in hydrogen and in nitrogen.

(2972) Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3803/47 (1947). This report of 1939 shows that W-Co-C alloys give higher hardness, but lower toughness values than W-Co alloys.

(2973) Hard Metal Compacts. Studiengesellschaft Hartmetall. F.D. Rept. No. 3804/47 (1947). According to studies in 1939, dense hard metal compacts can be obtained without pressing, shrinkage being approximately double that of the pressings. Blistering is oriented in the latter case, *viz.*, perpendicular to the direction of pressing, but without compaction blistering is random and spherical.

(2974) Hard Metals. Studiengesellschaft Hartmetall. F.D. Rept. No. 3805/47 (1947). According to this report of 1939, all hard metals are susceptible to anodic oxidation.

(2975) Sintering of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3822/47 (1947). A report in 1939 on comparative tests showing that sintered WC-TiC-Co made according to Ger. Pat. 622,347 (Krupp) was superior to cast WC-TiC made according to Brit. Pat. 331,121 (Krupp). The work was done in connection with an opposition lodged against the German patent.

(2976) Multiple Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3825/47 (1947). This report of 1939 shows that hardness zones in WC-TiC-Co are due to Co segregation.

(2977) Welding of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3828/47 (1947). Welding experiments with 1/8 in. edge cubes were made in 1940 with WC alone and with 0.5% and 1% Co on two steels. The welding temperature was lowered by sintering at 1600° C. (2910° F.) compared with 1450° C. (2640° F.) and also by admixtures of vanadium carbide and chromium carbide, but not by molybdenum carbide, tantalum carbide or zirconium carbide.

(2978) Hard Metal Cutting Tools. Studiengesellschaft Hartmetall. F.D. Rept. No. 3830/47 (1947). This report of 1940 states that the sharpness of the cutting edge of hard metal tools was decisively important for the surface finish of steel.

(2979) Acid Resistance of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3831/47 (1947). According to this report of 1940, both WC and WC-Co have good resistance to conc. phosphoric acid at 250° C. (482° F.).

(2980) Molybdenum Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3835/47 (1947). Summarizes the literature up to 1940 on MoC, the existence of which is regarded as uncertain. Experimentally it was shown that a molybdenum carbide with a higher carbon content than Mo_2C is formed when molybdenum dis-

solves in tungsten carbide, its rate of formation being accelerated in the presence of cobalt.

(2981) Metal Carbide Tips. Studiengesellschaft Hartmetall. F.D. Rept. No. 3836/47 (1947). Effect of sharpness of cutting edge of WC-TiC tips and of cutting speed on shape of steel chips is reported on in 1940.

(2982) Tungsten Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3841/47 (1947). According to this report, dating from 1940, additions of 1% or 3% boric acid to WC-Co produce increased porosity and formation of δ-phase.

(2983) Part 1. Sintering of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3843/47 (1947). This report, dating from 1940, states that WC-TiC-Co must be sintered in the presence of a liquid phase, since even 40 hours at 1350° C. (2460° F.) does not give the necessary density. WC-Co can be completely sintered at 1250° C. (2280° F.) for 30 hours, *i.e.*, without the presence of a liquid phase, and grain growth was also observed. The tips gave a cutting performance equivalent to that of normally sintered tips. The densification was ascribed to the solid solution of WC in Co from 1200° C. (2190° F.) upward.

(2983A) Part 2. Sintering of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3843/47 (1947). According to this report, also dating from 1940, considerable shrinkages were obtained with WC and 0.1% Co or 0.1-0.2% Fe (from ball-milling), the sintering conditions being 1700° C. (3090° F.) for 1½ hours. Prolonged ball-milling shifts the sintering temperature for equal density to lower values which are again increased when the Fe content from ball-milling is leached out with boiling HCl. The Fe content also promoted grain growth which increased with ball-milling time and sintering temperature. Pure WC showed as grain growth even at 1800° C. (3270° F.), while the presence of 0.1-0.2% Fe or Co produced noticeable shrinkage and grain growth from 1250° C. (2280° F.) onward.

(2983B) Part 3. Sintering of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3843/47 (1947). Experiments, conducted in 1940, with WC with 5% Cu (as copper oxide) and sintering at 1700° C. (3090° F.) showed that the tips, although fully sintered, had a cutting efficiency of only 50% of that of WC-Co.

(2983C) Part 4. Sintering of Carbides in 1940. Studiengesellschaft Hartmetall. F.D. Rept. No. 3843/47 (1947). It is stated that WC-Co tips sintered at 1250° C. (2280° F.) had in some instances a noticeably higher bending strength than tips made by normal sintering with a liquid phase. From the photomicrographs it can be seen that in the former grain growth proceeded rather irregularly.

(2984) Carbides for Cutting Steel. Studiengesellschaft Hartmetall. F.D. Rept. No. 3844/47 (1947). A discussion in 1940 of the differences between WC-Co and WC-TiC-Co for cutting steel, based partly on the "welding-on temperature" experiments.

(2985) Ball-Milling and Sintering of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3845/47 (1947). According to this report of 1940, dry-ball-milled tungsten carbide exhibits greater grain growth during sintering than wet-milled.

(2986) Boron Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3846/47 (1947). This report of 1940 summarizes briefly the work on cast and sintered boron carbide. Only the boron-carbides mentioned in an earlier report (F.D. Rept. No. 3778/47) appear to be promising as raw material.

(2987) Mechanism of Sintering of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3849/47 (1947). A summary of work till 1940 on the mechanism of carbide sintering.

(2988) Hardness of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3862/47 (1947). The hardness of WC-Fe specimens containing the δ-phase was measured on (*1*) furnace-cooled, (*2*) water-quenched, and (*3*) steel-backed specimens. Cutting tests and melting tests were made on 65:35 WC-Fe. Sintering experiments on WC-Fe were abandoned owing to the small difference between the sintering and melting temperatures. Cast and quenched 50:50 WC-Fe plus up to 3.5% C gave hardness values of 83-86 compared with 75-78 for similar cast WC-Co-C alloys. (Report dates from 1941).

(2989) Sintering of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3873/47 (1947). According to this report dated 1941, the sintering of WC is impeded by adding 10% zinc, tin, brass or bronze. Copper, silver or lead have a slight sintering effect, but all additions are inferior to that of 0.3% Fe.

(2990) Tungsten Carbide Alloy. Studiengesellschaft Hartmetall. F.D. Report No. 3877/47 (1947). Unsatisfactory results were obtained on 85% WC bonded with a 20% Co-Be alloy owing to pore formation.

(2991) Part 1. Sintering of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3878/47 (1947). Pore clusters were formed in WC-Co sintered at 1450° C. (2640° F.), owing to partial transformations of β into β'. (Report dates from 1940.)

(2992) Sintering of Carbides. Studiengesellschaft Hartmetall. F.D. Rept. No. 3880/47 (1947). WC-TiC-Co sinters with a TiC-free outer layer of 10-100 micron thickness as shown by cutting tests on non-ground and ground specimens on steel. It is therefore recommended that brazing should be done on non-ground surfaces. (Report dates from 1941.)

(2993) Part 1. Cutting Properties of Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3882/47 (1947). Metallographic tests in 1939 showed that good cutting performance of WC-Co is related to the presence of α_1 phase.

(2993A) Part 2. Grain-Refining Effect. Studiengesellschaft Hartmetall. F.D. Rept. No. 3882/47 (1947). According to this report of 1941, prolonged ball-milling (96 and 200 hours) and excessive compacting pressure (10 and 13 tsi) have both a grain-refining effect, but ball-milling more so, and the α-phase is less sharply developed.

(2994) Phases of Carbide Tips. Studiengesellschaft Hartmetall. F.D. Rept. No. 3884/47 (1947). Carbide tips made in 1941 with the admixture of 1% WC from Merck or Wesenfeld gave a noticeably finer α-phase.

(2995) Tensile Strength of Cemented Carbides. Studiengesellschaft Hartmetall. F.D. Rept. 3886/47 (1947). The tensile strength of cemented carbide G-1 specimens was approximately 130 kg./mm.2 (185,000 psi) at room temperature and 100 kg./mm.^{2} (145,000 psi) at 800° C. (1470° F.). (Report dates from 1941.)

(2996) Polished Hard Metal. Studiengesellschaft Hartmetall. F.D. Rept. No. 3888/47 (1947). Polished hard metal loses its luster on heating at 1000° C. (1830° F.) in a current of 3:1 nitrogen-hydrogen. (Report dated from 1941.)

(2997) Sintering Studies on Tungsten Carbide-Iron. Studiengesellschaft Hartmetall. F.D. Rept. No. 3892/47 (1947). This report of 1941 states that neither 50:50 WC-Fe nor 50:50 W_2C-Fe can be sintered.

(2998) Tests on Tungsten Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3898/47 (1947). Transverse rupture strengths of WC-Co leached with boiling HCl were reported in 1941.

(2999) Multiple Carbide Tips. Studiengesellschaft Hartmetall. F.D. Rept. No. 3907/47 (1947). With WC-TiC tips the bending strength decreases with increasing cobalt content. (Report dates from 1942.)

(3000) Binder for Hard Metals. Studiengesellschaft Hartmetall. F.D. Rept. No. 3911/47 (1947). It was found in 1942 that neither silver nor cobalt-silver alloys are useful binders for hard metal.

(3001) Part 1. Multiple Carbide System. Studiengesellschaft Hartmetall. F.D. Rept. No. 3913/47 (1947). An X-ray investigation was made in 1938-39 of the WC-TiC system, also duplicated with the addition of 5% Co. The Co does not affect the WC-TiC equilibrium, but it accelerates the rate of decomposition of the solid solutions. The solubilities of WC in TiC between 1300° C. (2370° F.) and 2200° C. (3990° F.) were determined. Between 1600° C. (2910° F.) and 2200° C. (3990° F.) less than 0.5% TiC is soluble in WC.

(3002) Boron Carbide. Studiengesellschaft Hartmetall. F.D. Rept. No. 3917/47 (1947). Boron carbide was sintered to theoretical densities with Ag, Cu, Fe, Mo, W, Mo_2C, WC, VC, TiC, Mo plus Mo_2C, W plus WC, and up to 50% C.1 hard metal. Cutting performance was in all cases nil, even after annealing at 1600° C.

(2910° F.) or 2000° C. (3630° F.) for 50 hours. Comparative metallographic tests on boron carbide specimens were made by Osram and the I. G. Farbenindustrie. (Report dates back to 1942.)

(3003) Admixtures to Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3922/47 (1947). In tests conducted in 1941-2 it was found that the admixture of various sulfides to WC-Co produces grain growth rather than grain refining. The same effect is produced by adding flowers of sulfur or by sintering in a hydrogen sulfide atmosphere. This point may be significant when running in new carbon tube furnaces.

(3004) Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3923/47 (1947). It was found in 1940 that tungsten carbide and copper have no mutual solubility.

(3005) Binder Metals for Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3940/47 (1947). Experiments on the total or partial substitution of Co with Fe and/or Ni as binder metal were reported in 1943. Fe impedes the grain growth of WC, and both Fe and Ni impede the formation of WC-TiC solid solutions.

(3006) Part 2. Densities of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3943/47 (1947). Factors affecting the difference between the theoretical and actual densities of WC-TiC are reported in 1942.

(3007) Widia Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3945/47. (1947). It is reported in 1943 that the grain size of the γ-phase in Widia tips has decreased consistently from 1939 onward.

(3008) Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3974/47 (1947). Effect of tempering and of sulfide admixtures on the grain shape of cast TiC-WC-Ni. Angular TiC or TiC-VC cannot be sintered to density without losing its angular shape. Microstructure of angular TiC-WC in WC-TiC hard metal. Properties of such hard metal. Effect of NiS on the grain shape of TiC. Effect of tempering on the γ-phase in WC-TiC hard metal. Tempering has the same effect of TiC bonded with either Co or Ni. The effect is not produced with TiC-Fe or TiC-Fe-C. Effect of grinding on VC and TiC specimens. (Reports date from 1941, 1942 and 1945.)

(3009) Titanium Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3976/47 (1947). Transverse rupture strength of TiC-VC materials is given in this report of 1945.

(3010) Microstructure of Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3980/47 (1947). Progress report in 1939 of work on the microstructure of hard metals.

(3011) Microstructure of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 4005/47 (1947). This report of 1941 compares the microstructure of WC and WC-TiC bonded with $FeAl_3$ and $TiAl_3$. It is stated that sintering of these materials is inferior to standard hard metal compositions with cobalt binder.

(3012) German Hard Metal Industry. G. J. Trapp, B. E. Berry, H. Burden, A. E. Oliver, and T. Raine, B.I.O.S. Final Rept. No. 1385, 1947, 453 pp. Methods for extracting W- and Co-salts from the ores carried out by Krupp; Osram and D. Edelstahlwerke–Metallwerke Plansee.

(3013) Sintered Carbides: Products and Properties. E. M. Trent, *Metal Ind. (London), 71*, 499 (1947). Tungsten carbide powders mixed with cobalt, pressed and heated above melting point of lowest-melting constituent; alloys could be produced much stronger than cast carbides and nearly as hard.

(3014) Production and Properties of Sintered Carbides. B. Zacharzewski, *Hutnik, 14*, No. 6, 292-301 (1947). The preparation and properties, including hardness, density, and thermal conductivity of a number of sintered carbides are discussed. The materials include WC with Co content and mixed W- and Ti-carbides.

(3015) Equipment for Production of Tungsten Carbide Parts. *Machinery (London), 72*, No. 1848, 398-99 (1948). Description of a complete set of equipment by J. Coltman, Ltd.

(3016) Tungsten Carbide in South Africa. *Metal Ind. (London), 73,* No. 9, 174 (1948). The main feature of the experiments is the use of tungsten carbide tipped drills, operating by rotation instead of the conventional percussive steel drills.

(3017) Cast Tungsten Carbide and the Production of Tungsten-Free Hard Metal. U. S. Dept. Comm., PB. 78259, 1948, 73 pp.; *Mats. & Mets., 27,* No. 3, 113-114 (1948). Ti and Va carbides are made in Germany by carburizing the oxide in H. The product is ball-milled, sifted, then ball-milled with Fe powder and sieved. The powder is compressed and sintered.

(3018) Modern Uses of Hard Metals. H. Burden, *Alloy Metal Rev., 5,* No. 47, 2-11 (1948). Classification; graphs showing variation in hardness and cross breaking strength in the variation of Co and Ti content.

(3019) Microstructure of Hard Metals Containing Titanium Carbide. H. Burden, *Met. Powd. Rept., 2,* No. 12, 184 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 193 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 12. Describes a heat tinting method for micro-examination, using an electric muffle furnace with direct observation.

(3020) On Knowledge of Hard Metals. W. Dawihl, *FIAT Rev. German Sci., 1939-1946: Non-Ferrous Metallurgy II,* 148-50 (1948). Sections deal with: formation and decomposition of WC; measurement of shrinkage force in sintering; globular crystal formation, formation of MoC; action of binding metals; wear resistance.

(3021) Structures of Hard Metal Alloys. H. Franssen, *Arch. Eisenhüttenw., 19,* 79-84 (1948). W-C, WC-Co, WC-TiC-Co alloys are examined on the basis of diagrams of state. WC produced by sintering is described in detail, and method of etching for distinguishing phases on the surface and for grain bounderies.

(3022) Magnetic Characteristics for Evaluation of Hard Metal Alloys. H. Franssen, *Arch. Eisenhüttenw., 19,* 85-89 (1948). Co can be determined by the measurement of magnetic saturation and by the coercive power; the coercive power can also be a measurement of the sintering action and the state of crystallization.

(3023) Tungsten Carbide–Free Hard Metals. R. Kieffer and F. Kölbl, *Met. Powd. Rept., 2,* No. 12, 185 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 28. Authors deal with combinations of metal carbides other than W carbide, especially TiC-Mo_2C and TiC-VC. Hot-pressing is preferred to vacuum sintering, and even more so to sintering in hydrogen. The carbides of metals of the 4th and 5th groups, which are mutually soluble mostly over the entire range, have a limited solubility only for the carbides of the 6th group, while inversely there exists practically no solubility.

(3024) Physical Investigation of Hard Metals. H. Krainer, *Met. Powd. Rept., 2,* No. 12, 186 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 193 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 31. The paper deals with magnetic saturation methods for determing the η-phase, by means of a magnetic bridge requiring field strengths of 8,000 to 10,000 gauss. F. Kölbl considered that electrical measurement would prove useful in determining the degree of sintering. R. Kieffer and D. H. Shute doubted whether x-ray methods could compare with chemical methods on question of cost.

(3025) Preparation and Properties of Alloys of Titanium- and Tungsten-Carbide. A. G. Metcalfe, *Met. Powd. Rept., 2,* No. 12, 184 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 14. The conditions for preparation of oxygen-free and carbon-saturated Ti carbide are discussed and compared with methods used at present industrially. Author's work on the Ti-W-C ternary diagram, and investigation of structure.

(3026) Cause of Defects in Sintered Hard Metals. A. E. Oliver, *Met. Powd. Rept., 2,* No. 12, 186 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 193 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 11. From practical point of view the paper explains how numerous defects arise through slight variations in material or manufacturing, *e.g.*, inclusions, cracks, dimensional inaccuracies, excessive grain growth, patches of Co or C, and porosity.

(3027) Titanium Carbide in Sintered Hard Metals. M. Oswald, *Met. Powd. Rept., 2*, No. 12, 185 (1948); *Oesterr. Chem. Ztg., 49*, No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 52. On the basis of research carried out until 1941 it was found that Ti carbide and W carbide combine under optimum conditions in the ratio 3:1, which represents practically equal weight.

(3028) Hard Metals from Sintered Carbides. R. Pinta, *Métallurgie et Construction J., 80*, No. 10, 31-39 (1948). The composition of carbides and the addition of cobalt are described. Solid solutions of WC and TiC are also discussed.

(3029) Report on Tungsten Carbide. E. L. Reed, AECU-110, U. S. Atomic Energy Commission Publ., 1948, 58 pp. (also NEPA-465). A review of the data available on W_2C, WC, $WTaC_2$, and $WTiC_2$. Data are given on the methods of preparation and fabrication, and a discussion of numerous high-speed tool materials based on the compounds is included.

(3030) Cemented Chromium Borides. S. J. Sindeband, *Met. Powd. Rept., 2*, No. 12, 186 (1948); *Oesterr. Chem. Ztg., 49*, No. 10/11, 195 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 61. The manufacture of chromium boride with 30% Ni as binder is described. This alloy has a Rockwell A hardness of 89 and a transverse rupture strength of 120,000 psi. Figures given for hot hardness were rather low, and it was asked in discussion how better values could be expected with such a high percentage of Ni.

(3031) Report on Tantalum Carbide. R. E. Tate, NEPA-531, U. S. Atomic Energy Commission Publ., 1948, 28 pp. (also AECU-105). A summary of the properties of TaC is given. Various methods of preparation are described and it is considered that the material is best fabricated by powder metallurgy techniques using Ni or Co as a binder and sintering in a hydrogen atmosphere.

(3032) Production of Hard Metals. G. J. Trapp, *Mech. World, 123*, No. 3192, 332-5 (1948). "Hard metal" is the name given to alloy range comprising hard metal carbides in combination with binder metal. Methods and uses in manufacture of carbides.

(3033) Widia Tungsten Carbide. E. M. Wilson, B.I.O.S. Final Rept. No. 1694, 1948, 7 pp.; *Met. Powd. Rept., 2*, No. 10, 153 (1948). Krupp used two methods of etching: (*1*) Electrolytic carried out at room temperature in 5% KOH at 4 volt for 1-4 sec. The WC and TiC phases are darkened, leaving Co unattacked. (2) In the heat tinting method the polished specimen is heated at 400° C. (750° F.) and the phases are distinguished by the color of their oxides.

(3034) Production and Properties of Sintered Carbides. B. Zacharzewski, *J. Iron Steel Inst., 160*, No. 1, 113 (1948). Cf. *Hutnik, 14*, No. 6, 292-301 (1947).

(3035) Metallographic Study of Cemented Carbides. N. M. Zarubin, *Zavodskaya Lab., 14*, 1434-1436 (1948). Study of most suitable selective etchants for cemented carbides in micrographic analysis. Materials used in study: WO + Co; Mo_2C + Co; TaC + Co; also Cr_3C_2 + Co, with different carbide contents.

(3036) Zirconium Boride Compound. *Materials and Methods, 30*, No. 6, 41 (1949). The new alloy was developed under an Office of Naval Research contract by American Electro Metal Corp., and in tests, this material has survived higher temperatures than any material previously used in the experiment.

(3037) J. Barksdale, *Titanium – Its Occurrence, Chemistry and Technology.* Ronald Press, New York, 1949. Chapter 23 refers to hard metal alloys.

(3038) Elevated-Temperature Properties of Titanium Carbide Ceramals. G. C. Deutsch, A. J. Repko, and W. G. Lidman, *National Advisory Comm. Aeronautics, 1915*, 1949, 47 pp. Investigation was made from 870-1300° C. to obtain information on bonding mechanism. The composition was TiC plus 5, 10, 20, and 30% of W, Mo, and Co. Density, tensile strength, coefficient of linear expansion, and oxide-coating composition were determined.

(3039) Sintering Carbides by Means of Fugitive Binder. L. S. Foster, U. S. Atomic Energy Comm., AECD-2464, 1949, 35 pp. Development of method for production of pure WC, CbC, and TaC having zero surface-connected porosity and nearly the theoretical density are made by grinding the carbides to a very fine powder, admixing small amount of binder, sintering and distilling off the binder metal in vacuo.

(3040) Structure of Hard Metal Alloys. H. Franssen, *Stahl u. Eisen, 69,* 169 (1949). The changes in the structure during melting and sintering are investigated.

(3041) Initial Investigation of Carbide-Type Ceramal of 80% Titanium Carbide Plus 20% Cobalt for Gas-Turbine Blade Material. C. A. Hoffman, G. M. Ault, and J. J. Gangler, *Natl. Advisory Comm. Aeronautics, Tech. Note No. 1836,* 49 pp. (1949). The tensile strength of 80:20 TiC-Co at 980° C. (1795° F.) in helium was 33,200 psi and 13,000 psi at 1200° C. (2190° F.). Resistance to thermal shock was measured by heating and air quenching, repeated until failure occurred.

(3042) Sintered Hard Metals. R. Kieffer and F. Benesovsky, *Werkstatt u. Betrieb, 82,* No. 5, 145-8 (1949). Group WC-Co and WC-Ti-Co, as wear resisting materials; hardness and bending strength; advantages in machine manufacture; careful choice of hard metal for cutting and measuring tools; illustrations.

(3043) Tungsten Carbide-Free Hard Metals. R. Kieffer and F. Kölbl, *Powd. Met. Bull., 4,* No. 1, 4-17 (1949). Hard alloys containing no metal carbides are only of limited usefulness; tungsten carbide can, however, successfully be replaced by metal carbides of 4th, 5th and 6th groups of periodic system; titanium carbide appears most suited as main constituent of tungsten free cemented carbides; carbides of vanadium, columbium and molybdenum, which all are readily sintered, are most interesting as additional carbides.

(3044) Reproducibility of Tungsten Carbide in Milling of Cast Iron. K. G. Lewis, *Iron & Coal Trades Rev., 158,* No. 4227, 563-70 (1949). Tests demonstrate existence of material capable of meeting all practical requirements; work described was outcome of investigation on negative rake milling of cast iron: test conditions described and usefulness of fly cutting as basis of test is outlined.

(3045) Cemented Titanium Carbide. J. C. Redmond and E. N. Smith, *Trans. Am. Inst. Mining Met. Engrs., 185,* 987-93 (1949). The authors give away a considerable amount of laboratory data that has been accumulated at Kennametal, Inc., dealing with oxidation resistance of TiC-Co, and Cb-Ta-Ti carbide; and dealing with transverse rupture strength of TiC with binder.

(3046) Control of Properties of Sintered Hard Metals. E. J. Sandford, *Alloy Metal Rev., 7,* No. 52, 2-12 (1949). Choice of carbides; influence of Co content; other binders than Co; influence of the grain size effect on the manufacturing technique.

(3047) Sintered Hard Metals Containing Titanium Carbide. E. J. Sandford, *Alloy Metals Rev., 7,* No. 54, 2-11 (1949). Contains a historical account of the development of sintered tungsten carbide-titanium carbide-cobalt alloys and an outline of the theories advanced to explain the beneficial effect of titanium carbide when machining steel. Production problems are considered. The influence of oxide is emphasized and various photomicrographs are shown.

(3048) Properties of Chromium Boride and Sintered Chromium Boride. S. J. Sindeband, *Trans. Am. Inst. Mining Met. Engrs., 185,* 198-202 (1949). Study initiated as approach to problem of material for service at high temperatures under oxidizing atmospheres; summary of requirements; pressing and sintering of chromium boride; high temperature testing; only one chromium boride compound exists in range 12% to 20% boron content, instead of two, as had previously been reported; results of investigation of pressing and sintering of chromium boride with nickel as binder. Bibliography.

B. Hard metal applications (tools, dies, wear- and heat-resistant parts)

(3049) German Alloy of Diamond Hardness. *Iron Age, 116,* 151 (1925). An alloy consisting of W carbide and W has a hardness of 9.9 on the Mohs' scale, is suitable for dilling purposes, and is produced under the trade name "Thoran."

(3050) Hardest Alloy for Boring Purposes. *Montan. Rundschau, 17,* 778 (1925). "Volamit" consists of W carbide and W and is used instead of diamonds.

(3051) Cutting with Cemented Carbides. W. C. Drescher, *Siemens-Jahrbuch, Berlin*, 1927, pp. 435-454 (1927). Machining of porcelain and glass on the lathe are described.

(3052) Tools with Inserts of Hard Metal. W. C. Drescher, *Masch.-Bau Betrieb, 7*, 49-55 (1928). The development of hard metal tools is described.

(3053) Carboloy – A New Tool Material. S. L. Hoyt, *Gen. Electriv Rev., 31*, 585-91 (1928). By means of addition of Co, a W carbide is made half as strong as high-speed steel, while the hardness is retained to such an extent that it will scratch sapphire. Results of tests carried out with "Carboloy."

(3054) High-Speed Cutting Metals. G. J. Weissenberg, *Metallwirtschaft, 7*, 1031-6 (1928). A review of the developments and properties of steels and non-ferrous alloys for use in high-speed cutting alloys includes Widia hard metal.

(3055) The German Tool Metal "Widia" and the American Tool Metal "Carboloy." A. Hofmann, *Werkzeugmaschine, 33*, 117-90 (1929); *J. Inst. Metals, 42*, 641 (1929). A survey of the development of cutting tool alloys and a comparison of the two types of material.

(3056) Harder Metals Are Now Workable with Cemented Tungsten Carbide. S. L. Hoyt, *Automotive Ind., 61*, 653-5 (1929). Manufacture of cemented carbide tools. Cobalt acts as cement. Lapped with B-carbides. Grinding for non-ferrous metals.

(3057) Superhard Metals for Tool Facings. H. J. Morgan, *Trans. Am. Inst. Mining Met. Engrs., 86*, 308-310 (1929). Drilling bits faced with W-carbide in oil-field work are discussed. A new abrasion test machine is described.

(3058) Widia, Its Development and Shop Application. R. D. Prosser, *Trans. Am. Soc. Mech. Eng., 51*, 10-16 (1929). Regrinding of Widia tools is stated to be required less frequently than with high-speed tool steel.

(3059) Tungsten Carbide. *Engineers & Engineering, 47*, No. 1, 36-7 (1930). Describes the development of W carbide cutting tools. Important limitation is imposed by frequent breakdown of cemented carbide under heavy pressure.

(3060) Application of Tungsten Carbide Tools in America. *Werkzeugmaschine, 34*, 253-58 (1930). A review of progress in research and application.

(3061) High-Finish Grinding of Hard Metal Tools with Boron Carbide. W. Dawihl and E. Wesenberg, *Werkstattstechnik & Werksleiter, 33*, 373-76 (1939). Description of technique.

(3062) Widia Metal in Industry. A. Fehse, *Chem. Zentr., II, 101*, 2302 (1930). Methods of using Widia metal as a tool are described. The soldering on of cutting edges of Widia; choice of the cutting angle; the shaping of the tools.

(3063) The Present Status of Cemented Tungsten Carbide Tools and Dies. Z. Jeffries, *Trans. Am. Soc. Mech. Engrs., 52*, 29-37, MSP-52-3 (1930). Discussion of the superiority of a tungsten carbide die over other types of drawing dies.

(3064) Hard Metal Dies for Wire Drawing. S. C. Lawson, *Wire and Wire Products, 5*, No. 5, 162-3, 180-1 (1930). Description of a new series of tungsten-carbide dies with remarkable performance record.

(3065) Production and Properties of Crucible from Carbides and Nitrides. O. Meyer, *Ber. deut. keram. Ges., 11*, 333-363 (1930). Sintered titanium nitride is recommended as a crucible material for carbon-rich ferrous melts up to 1700° C. (3100° F.).

(3066) Tungsten Carbide Tools. R. D. Prosser, *Trans. Am. Soc. Steel Treat., 17*, 749-64 (1930). The interest of W carbides at Krupp A. G. Description of the results obtained in production work and instructions for application, grinding and uses for these tools.

(3067) Tungsten Carbide Cutting Material. F. A. Spencer, *Trans. Am. Soc. Mech. Engrs., 52*, 171-75 (1930). In the machining of silicon-aluminum alloys, carbide tools produced 4,500-35,000 pieces per grind against 100-1800 pieces per grind when using high-speed steel.

(3068) Test for Mechanical Power of Widia Tools. A. Fehse, *Masch.-Bau Betrieb, 10*, 161-73 (1931). Turning of different metals with Widia tools is investigated.

(3069) Proper Grinding of Tungsten Carbide Tools and Cutters. R. D. Prosser, *Iron Age, 128,* No. 22, 1357-58; No. 24, 1479-80 (1931). The grinding practices of Widia (Krupp A.G.) are determined by extensive research. The proper maintenance of Widia-tipped milling cutters.

(3070) Cutting Steel with a New Cemented Carbide. R. D. Prosser, *Machinery (N. Y.), 38,* No. 4, 296 (1931). Results of tests conducted on Widia X to determine its capacity for machining steel, Widia X is mixture of several carbides held together by binder.

(3071) "Widia." K. Schröter and A. Fehse, *Wiss. Veröffentl. Osram Konzerns, 2,* 207 (1931). Widia cutting tools; their properties and uses described.

(3072) Cemented Tungsten Carbides for Cutting Tools. L. J. St. Clair, *Trans. Am. Soc. Mech. Engrs., 53,* MSP-15, 139 (1931). Design and care of the tools are essential factors in a successful application. A proper support of the tips and an allowance for proper clearance angles are essentials of the design.

(3073) Widia Metal in Industry. A. Fehse, *Werkstattstechnik, 24,* 237-44 (1932). The soldering on of cutting edges of Widia; choice of the cutting angle; the shaping of the tools.

(3074) Working Glass with Widia Tools. A. Fehse and B. Kindt, *Glasstechn. Bericht, 10,* 193-200 (1932). Difficulties of glass working, differences between glass and metal working and use of Widia for boring and cutting of glass.

(3075) Hard and Super-Hard Alloys of U.S.S.R. A. M. Kasparow, *Moscow: Zwetmetisdat,* 1932, 120 pp. Description of composition and uses of different tool material grades, including newly developed cemented carbide (*e.g.*, "Pobedit").

(3076) How Carboloy Tools Are Made. A. McKenzie, *Machinery (N. Y.), 38,* 727-30 (1932). Processing of the hard metal is described; pressing, presintering, final sintering and attaching of the tool tips to the shanks is described.

(3077) Tests With Hewing Tools. J. Mencke, *Glückauf, 68,* 337-43 (1932). Tests with Widia tools are described.

(3078) Variety of Grades Opens New Fields for Cemented Carbides. R. D. Prosser, *S. A. E. Journal, 31,* No. 4, 11-14 (1932). Time, economy, the saving of extra finish cuts and more work between grinds continue to be the outstanding advantages of this cutting material.

(3079) Technology of Hard Alloys, and Application in Industry. A. I. Resnikov, *Moscow: Zwetmetisdat,* 1932, 130 pp. Review of materials, production, and, in particular, applications.

(3080) Hard Alloys Used for Drilling. G. E. Varshavskii and N. L. Vartametov, *Gooznenskii Neftyamik, 2,* No. 7-8, 47-54 (1932). Hard alloys used for rotary drilling tools.

(3081) The Hard Metal "Widia" in the Hands of the Chemist. C. Agte, *Chem. Fabrik, 6,* No. 1, 5-6 (1933). Widia is metal of Fe-group impregnated with WC. Glass may be shaped with it and it is therefore suitable for glass cutters, mortars, etc.

(3082) Brazing Drilling Bits with "Vokar" and "Pobedit Alloys". V. S. Fedorov and N. G. Postarnak, *Neftyamoe Khozyaistvo, 24,* 109-12 (1933). "Vokar" is a mixture of W and C. "Probedit" has 5-6% C, 80-83% W, 7-8% Co, 5-6% Fe, 2% Mo. Brazing technique is described in detail.

(3083) The Economic Uses of Cemented Carbide and Other High-Duty Alloy Tools. E. W. Field and J. H. Garnett, *J. Inst. Production Engrs., 21,* 224-51 (1933). Tungsten-carbide alloys are reviewed and their physical properties listed.

(3084) Modern Metal Cutting Materials and How to Select Them. J. H. Highducheck, *Machinery (N. Y.) 40,* No. 1, 12-17 (1933). Results of extensive tests at the East Pittsburgh Plant of Westinghouse Co. serve as a guide in selecting cutting materials.

(3085) From Tungsten Powder to Finished Carbide Tools. *Iron Age, 135,* No. 5, 30 (1935). A pictorial description of the Carboloy process of making cemented carbide tools.

(3086) Deposition Welding of Hard Metal Pieces for Tools. E. Ammann, *Werkzeugmaschine, 39,* 429-34 (1935). The use of tungsten carbides, Stellite, Verdur, and Widia metals for this purpose is described.

(3087) Hard Metal Tools. K. Becker, *Hartmetallwerkzeuge.* Verlag Chemie, Berlin, 1935. Preparation of the tools, their construction; use and economy; occurrence with the cutting.

(3088) Hard Metals for Mining. K. Becker, *Elektr. im Bergbau, 10,* 93-96 (1935). The use of cemented carbides for mining tools is discussed.

(3089) Hard Metal in the German Industry. K. Becker, *Werkzeugmaschine, 39,* 440-43, 451 (1935). The efficiency of sintered carbide tools as compared to high speed steel is discussed.

(3090) M. Bonzel, *Steel Wire, Manufacture and Properties.* Engineers Book Shop, New York, 1935, 495 pp. Carbide-base hard metal dies are discussed on pp.88-93.

(3091) Widia Edges of Drills for Hard Rocks. O. Müller and H. Wohlbier, *Krupp Monatsh., 13,* 89-98 (1935). The construction and the use of drills with Widia edges are described.

(3092) Effect of Die Angle, Lubricant, and Drawing Velocity on Power Requirements in Drawing Light Gage Steel Wire. A. Pomp and H. Heckel, *Mitt. Kaiser-Wilhelm Inst. Eisenforsch. Düsseldorf, 17,* 107-26 (1935). Drawing tests with dies from Widia are described.

(3093) Present Status of Cemented Carbides and Other Modern Cutting Materials. R. D. Prosser, *Am. Soc. Mech. Engrs. Progress Rept. No. 4,* Subcommittee on Metal Cutting Materials, 1935. A review gives information on cutting speeds and efficiency in conjunction with machining different materials.

(3094) Use of Hard Metal in Potassium Industry. V. Bakul and A. Kolesnikov, *Kalii (U.S.S.R.), 5,* No. 2, 18-23 (1936); *Met. Abstr., 3,* 282 (1936). Description of use of (*1*) Stalinit composed of 9.5% Cr, 11.5% Mn, 12.5% C, 55.5% Fe. (*2*) Pobedit, a mixture of W and Co pressed and sintered.

(3095) Chip Forming Machining With Hard Metal Cutting Tools. H. Beutel, *Die Werkzeugmaschine, 39,* 436-39, 485 (1936). Construction of cutting tools, shaping of drills, and working conditions for titanium drills are discussed.

(3096) A. N. Gladilin, *Hard Alloy Tools and Cutting of Metals.* Gonti, Moscow, 1936, 212 pp. Review in book form includes cemented carbide tools.

(3097) A New Carbide Metal of Special Toughness for Edged Tools: Böhlerit E. H. Holzberger, *Tech. Z. Praktische Metallbearbeitung, 46,* 10-12 (1936); *Chem. Zentr., 107,* I, 3210 (1936). Detailed description of its superior cutting quality.

(3098) Results Obtained in Machining with Tantalum-Carbide Tools. P. M. McKenna, *Machinery (N. Y.), 43,* 24-9 (1936). Recent development in Carbide Cutting Tools and detailed data on metal cutting based on actual production results in the shop.

(3099) Cemented Carbide-Fitted Saws and Woodworking Knives. C. M. Thompson, *Trans. Am. Inst. Mining Met. Engrs., WDI 59-1,* 121-124 (1936). Industrial applications of cemented carbides are described.

(3100) Modern Tungsten Carbide Tool Manufacture. *Heat Treating & Forging, 23,* 271-3 (1937). New sintered carbide plant of Firth-Sterling Steel Co.

(3101) C. Agte and K. Becker, *Hartmetallwerkzeuge.* Chemie, Berlin, 1937, 235 pp. Sintered Carbide Tools are treated in considerable detail. (2nd edition of K. Becker, *Hartmetallwerkzeuge,* 1935.)

(3102) The Application of Hard Metal Tools in the Chemical Industry. K. Becker, *Chem. App., 24,* 33-5 (1937). Hard metal tools can be used not only on metals, but also on stoneware, glass, porcelain, etc. Several hard alloys are described.

(3103) Alloys for Tool and Wear Resistance. Z. Jeffries, *J. Applied Phys., 8,* No. 6, 380-84 (1937). Refers to tantalum carbide and titanium carbide for cutting steel.

(3104) F. W. Leier, *Hartmetalle in der Werkstatt.* Springer, Berlin, 1937, 51 pp. Applications of sintered carbide tools in the shop discussed in detail.

(3105) Twelve Carbide Tools Turn Ford Drive Shafts Simultaneously. C. G. Williams, *Machinery (N. Y.), 44,* No. 2, 109-110 (1937). Description of application with illustrations.

(3106) Cutting Tools Research. *Proc. Inst. Mech. Eng., 139,* 3-39 (1938); *Summaries Engineer, 165,* 431-432, 457-458 (1938); *Engineering, 145,* 430-432, 516-518 (1938). Report of Subcommittee on Carbide Tools.

(3107) Tungsten Carbide in Hard Surfacing Oil Well Bits. N. J. Clark, *Foote Prints, 11,* No. 2, 15-19 (1938). A number of alloys were used over a period of time. Mn, Cr, Mo, Co, W, were favorite alloying elements. Carbides, borides, nitrides offered some promise.

(3108) Alloys Used for Cutting Tools. H. D'Arcambal, *Usine, 47,* No. 35, 25-27 (1938). Properties and applications of sintered carbides.

(3109) The Limit of Economy in Turning of Steel by Hard Metal Tools. W. Dawihl, *Maschinenbau-Betrieb, 17,* 511-13 (1938). It was proved by tests that hard metal tools could be used economically at cutting speeds above 30-40 m/min.

(3110) Industrial Use and Development of Sintered Carbides. M. F. Judkins, *Tech. Eng. News, 19,* No. 4, 81-83 (1938). Sintered carbide tipped tools are described.

(3111) Cutting Efficiency of Cemented Carbides and High Speed Steels. F. Rapatz, H. Pollack, and J. Holzberger, *Stahl u. Eisen, 58,* 256-76 (1938). Sintered TiC and WC tools and 18-4-1 high speed steels are compared.

(3112) H. Schallbroch and R. Wallichs, *Werkzeugverschleiss.* Ver. deut. Ing., Berlin, 1938. Experiments are reported on the cutting performance of cemented carbides, and it is shown that oxide films tend to prevent welding between the hard metal tool and the work.

(3113) Cutting Tools for Cast Iron. H. H. Beeny, *Foundry Trade J., 60,* 571-574 (1939). Advantages of sintered W-carbide tools discussed.

(3114) The Carbide Die: History, Manufacture and Use. E. W. Engle, *Wire and Wire Products, 14,* 319-24, 350-1 (1939). A descriptive review is given of the subject.

(3115) A. Fehse, *Hartmetallwerkzeuge,* Ausschuss für wirtschaftliche Fertigung, Leipzig, 1939, 110 pp. Properties of standardized hard metals and production of tools of hard metals. Their uses and the technical and economic advantages in operating with hard metal tools. Demands on the machine tools.

(3116) Reduction of Wear by the Use of Hard Metal. J. Hinnüber, *Z. wirtschaftliche Fertigung, 43,* No. 9, 1-7 (1939); *Chem. Zentr., III,* I, 282 (1940). General behavior of sintered hard metals during the cutting of Al-alloys, at the turning of steel, and at the working of granite.

(3117) Hard Carbides. Z. Jeffries, *Metals & Alloys, 10,* No. 10, A58 (1939). Uses of cemented carbide dies.

(3118) Industrial Use and Development of Sintered Carbides. M. F. Judkins, *Tech. Eng. News, 20,* No. 1, 5-7, 18-21 (1939). Sintered carbide tipped tools are described. Continuation of *Tech. Eng. News, 19,* No. 4, 81-83 (1938).

(3119) New Developments in Machining Steel with High Carbide Tools. P. M. McKenna, *Modern Machine Shop, 12,* 60-68 (1939). Descriptive. Tools made from W-Ti-carbide ($WTiC_2$) are very suitable for machining materials that produce a crumbly chip.

(3120) Hard Facing of Oil Well Drilling Bits With Cast Tungsten Carbide. C. H. Shapiro, *Metal Progress, 35,* No. 4, 363-7 (1939). W-carbide compared with a newly introduced Cr-boride crystal material as hard facing alloy.

(3121) Application of Carbide Tools In Machine Tool Plant. *Machinery (London), 57,* No. 1468, 235-236 (1940). Cemented carbide tools effectively used for machining steel, cast iron and non-ferrous metals.

(3122) Tungsten-Titanium Carbide. *Metals & Alloys, 12,* No. 1, 6 (1940). Commercial notice of Kennametal material for tool applications.

(3123) Steel Cutting Carbide Tools. *Metals & Alloys, 12,* No. 2, 175 (1940). Commercial notice on carbide tools.

(3124) Carbides for Small-Lot Work. P. A. Abe, *Iron Age, 146,* No. 3, 44-5, 86-7, (1940). Three principles are important in changing over to carbide tools: (*1*) The machine must have plenty of drive power. (*2*) Support for the work rigidly. (*3*) Support the tool rigidly, so it won't chatter.

(3125) Production of Small Hard Metal Tips. C. Ballhausen, *Maschinenbau-Betrieb, 19,* No. 9, 373-4 (1940). Carbides of tungsten and titanium and Co-powder used in the manufacture of tool tips, bits, etc.

(3126) Carbide Tools for Machining Small Lots. F. S. Blackall, Jr., *Steel, 107,* No. 5, 54 (1940). Carbide tools show 25% savings over high-speed tools and permit carbide to be used economically even on smallest lots.

(3127) Mirror Strip with Carbide Rolls. T. C. Campbell, *Iron Age, 145,* No. 5, 44 (1940). By combining the use of hard, dense W-carbide work roll with improvements in cold Steckel mill and its operations, the speed came up to 2500 ft. per min. on carbon steels, to produce a mirror finish.

(3128) New Cutting Tools Will Speed Up Old Machines. D. G. Clark, *Metal Progress, 38,* No. 2, 182 (1940). Tungsten-carbide and cobalt super high speed cutting materials newly developed.

(3129) On the Grinding of Hard Metal Tools with Silicon-Carbide Wheels and the Measuring of the Cutting Quality. W. Dawihl, *Schleif u. Poliertechnik, 17,* No. 9, 127-31 (1940). Description of grinding technique; testing and control.

(3130) Sintered Carbide Tools Having Improved Supports. A. Heiman and A. M. Maizel, *Azerbaidzhanskoe Neftyanoe Khoz., 20,* No. 12, 37-40 (1940). Russian carbide tools are claimed to give 3 to 6 times the service life of American tools because of better cutting support.

(3131) An Industrial Application of Electrically Cleaned Air. W. J. Loach, *Machinery (N. Y.), 46,* No. 12, 89-90 (1940). The use of the precipitron has materially reduced the rejections in making sintered carbide tools.

(3132) The Broad Field of Use for Cemented Carbides. J. R. Longwell, *Wire and Wire Products, 15,* No. 5, 251-71 (1940). W-carbide, Ta-carbide, Ti-carbide hard materials and their uses described.

(3133) Carbides for Cutting Steel. P. M. McKenna, *Am. Machinery, 84,* No. 23, 917 (1940). Carbide-tipped boring tools. Facing cuts in steel. Carbide-tipped form tools. Cut-off tools.

(3134) Application of Carbide Tools in Machine Tool Plant. B. Merwin, *Machinery (London), 57,* No. 1469, 257-60 (1940). Recommended types of tools, speeds, feeds and depths of cut for machining different materials with cemented carbide.

(3135) Carbide Tools, Control and Use in the Shop. G. G. Thompson, *Iron Age, 145,* No. 19, 48-54 (1940). Determining the different styles of cutting tools which would be required; they are listed on charts.

(3136) Chip Curlers for Carbide Tools. G. G. Thompson, *Iron Age, 146,* No. 1, 25-8 (1940). Chip curler dimensions for carbide tools which have been proved satisfactory are listed.

(3137) Making Carbide Tools. G. G. Thompson, *Iron Age, 146,* No. 21, 43-6 (1940). Different forms of carbide tools are described.

(3138) How to Finish Carbide Drawing Dies. *Iron Age, 147,* No. 5, 48 (1941). Brief note on development of complete line of equipment for finishing and servicing as announced by Carboloy, Inc.

(3139) Carbides from Powder to Tool Bits. *Iron Age, 148,* No. 17, 36-7 (1941). Brief paragraph and photos showing how Carboloy Co. has adapted mass production methods to powder metallurgy.

(3140) The Process of Wearing of Sintered Carbide Materials. W. Dawihl, *Stahl u. Eisen, 61,* 210-13 (1941). Efficiency of carbide cutting tools decreases with increased cutting speed and improper lubrication.

(3141) Tools for Defense. F. K. Deak, *Mill and Factory, 28,* No. 3, 65-7, 248; No. 4, 91-5 (1941). Notes on selection and application of modern tool materials.

(3142) Use of Several Cemented Carbide Compositions on the Same Tool. E. Dinglinger, *Werkstattstechnik u. Werksleiter, 35,* No. 10, 173-176 (1941). Present status of cemented carbide compositions for cutting purposes.

(3143) Wire Manufacture. P. L. Herz, *Wire and Wire Products, 16,* No. 2, 109-114 (1941). Notes on production of fine wire, in order to make further progress; tungsten carbide drawing dies discussed.

(3144) The Use of Hard Metal for Percussion Rock Drilling. H. Jeschke, *Glückauf, 77,* 570-74 (1941). Hard metal tools and their instruments are described.

(3145) Titanium-Tungsten Carbide Cutting Tools. J. W. Jones, *Chem. Age (London), 45,* No. 1155, 91-2 (1941). Methods of chemical analysis as production control means are described.

(3146) Machining Shell With Carbide Tools. M. F. Judkins, *Mech. Engineering, 63,* No. 12, 859-60 and 869 (1941). Getting best results from carbide tipped tools.

(3147) Time Savings with New Steel Cutting Tools. W. L. Kennicott, *Western Mach. & Steel World, 32,* No. 5, 238-40 (1941). Kennametal performance discussed.

(3148) Calculation Chart for Maximum Shell Production. M. Kronenberg, *Can. Machinery, 52,* No. 11, 46-8, 99-100 (1941). Sintered carbide tools application described.

(3149) Shell-Machining Chart. M. Kronenberg, *Machinery (N. Y.), 47,* No. 9, 741-5 (1941). Tool life of high-speed steel and sintered carbide tools compared.

(3150) Grinding Carbide-Tipped Tools for Shell Turning. E. T. Larson, *Grits & Grinds, 32,* No. 11, 8-11 (1941). Procedure discussed.

(3151) Flying Chips Take Horsepower. J. Lawrence, *Am. Machinery, 85,* No. 9, 378-80 (1941). General discussion of cemented carbides.

(3152) Coolants for Cutting Steel with Carbides. J. R. Longwell, *Iron Age, 147,* No. 10, 53 (1941). Coolants applied through pipes.

(3153) Tungsten Carbide Dies. J. R. Longwell, *Steel, 108,* No. 3, 70-72 (1941). Dies for wire-drawing described.

(3154) Tungsten Carbide Dies and Tools. J. R. Longwell, *Wire and Wire Products, 16,* No. 1, 37-9, 43-4 (1941). Growth of W-carbide dies and their application in wire industry.

(3155) Critical Speeds for Carbides. R. H. McCormick, *Am. Machinery, 85,* No. 22, 1090-91 (1941). Details of simple cutting test.

(3156) Steel-Cutting Carbide Tipped Tools. P. M. McKenna, *Aero Digest, 38,* No. 1, 110-112 (1941). Performance of new tool composition (Kennametal) containing non-cratering long-wearing compound of tungsten-titanium carbide ($WTiC_2$).

(3157) Steel-Cutting Carbide Tools. P. M. McKenna, *Can. Machinery, 52,* No. 12, 212, 214, 242 (1941). Their design and power requirements discussed.

(3158) Procedure for Selecting Carbide Tool Shank and Tip Sizes. P. H. Miller, *Aero Digest, 39,* No. 4, 350 (1941). Chart for determining shank size is presented.

(3159) Carbide Cutting Tools. P. H. Miller, *Am. Machinery, 85,* No. 10, 773-775 (1941). Optimum tip thickness, shank size, etc. discussed.

(3160) Carbide Tools Brazed at Low Cost. W. S. Morse, *Iron Age, 147,* No. 4, 32 (1941). Method employed at Morse Tool Co., Detroit. 2000 pieces per 16 hours produced.

(3161) Performance of Cutting Tools. L. J. St. Clair, *Iron Steel Engr., 18,* No. 12, 61-3, 70 (1941). A list of each type of tool with regard to their "red" hardness or operating hardness.

(3162) How to Grind Steel-Cutting Carbide Tools. G. G. Thompson, *Iron Age, 148,* No. 11, 41-4 (1941). Malpractice is pointed out and corrections recommended.

(3163) Carbide-Tipped Tools for Boring Operations. G. G. Thompson, *Machinery (N. Y.), 47,* No. 2, 105-6 (1941). Developments in standardizing carbide boring tool bits to improve cutting action.

(3164) Machining Shells With Carbide Tools or How to Tell When to Sharpen Carbide Tools. G. G. Thompson, *Steel, 109,* No. 4, 62-4 (1941). Causes of failure of carbide tool tips discussed.

(3165) Steel Cutting Carbide Tools. G. G. Thompson, *Tool Engr., 10,* No. 12, 58-60 and 62 (1941). Breakability. Class of finish. Automatic machines. Interrupted cuts.

(3166) Tool Angles for Steel Cutting With Carbides. H. S. Wilcox, *Iron Age, 147,* No. 12, 39-45 (1941). Tests made on power consumption of carbide tools with 12 different combinations of cutting angles.

(3167) Machining Costs Reduced by Use of Carbide Tools. W. J. Williams, *Machinery (London), 59,* No. 1518, 173-5 (1941). Economy of cemented carbide tools discussed.

(3168) How Carbide Tools Reduce Cost of Machining Steel. W. J. Williams, *Machinery (N. Y.), 47,* No. 6, 122-5 (1941). Detailed account with specific examples. Reduction of cost at Nuttall Plant of Westinghouse Co.

(3169) Cemented Carbide Tools. *Automotive Eng., 32,* No. 421, 91-94 (1942). Outstanding properties are hardness and great resistance to abrasion. Brazing solders; elimination of vibration in the use of cemented carbide tools, uses also in dies, for wires, pipes and rod-drawing.

(3170) Brazing Carbide Tips on Tools. *Automotive Ind., 86,* No. 1, 25, 80 (1942); *Ind. & Welding, 15,* No. 1, 24-25 (1942). Torch brazing procedure described.

(3171) New Canadian Carbide Tool Plant Helps War Production. *Can. Machinery, 53,* No. 2, 55-7, 74 (1942). Description of equipment at plant of A.C. Wickman, Canada.

(3172) More Production from Old Machine Tools. *Iron Age, 149,* No. 6, 55 (1942). Application of cemented carbides.

(3173) Mechanical Clamp for Carbide Tip. *Iron Age, 149,* No. 22, 56-7 (1942). Clamping of cemented carbide cutting tips has enabled the contractor to double the tool life per grind.

(3174) Reshaping Carbide Tools for Special Operations. *Machinery (London), 60,* No. 1530, 64-65 (1942). The procedure is discussed with the aid of illustrations.

(3175) Recommended Tool Angles for Carbide Tools. *Machinery (London), 61,* No. 1576, 719 (1942). Table giving detailed data is presented.

(3176) Cemented Carbide Tipped Tools Increase Efficiency in Railroad Maintenance Shops. *Machinery (N.Y.), 49,* No. 2, 168-8 (1942). Applications for carbide tipped tools are enumerated.

(3177) Get Maximum Service from Carbide Tipped Tools. *Mill & Factory, 30,* No. 5, 93-106 (1942). Tool craftsmanship charts are given.

(3178) Carbide Cutting Tools in Pump Manufacture. *Western Mach. & Steel World, 33,* No. 1, 52-4 (1942). Carboloy tools on Bullard vertical turret lathe are described.

(3179) Developing Efficient Procedure for Machining Motor Shafts. C. J. Andersen, *Machinery (N. Y.), 48,* No. 7, 136-8 (1942). Carbide tools are used for this purpose.

(3180) Powder Metallurgy Discussed in Talk on Carbide Tools. J. P. Beal, Jr., *Metals Rev., 15,* No. 6, 7 (1942). Report on talk by Paul Judkins, "Sintered Carbide Tipped Tools."

(3181) Hyper-Mills Cut Double to Six Times As Much Metal. D. G. Clark, *Metal Progress, 42,* No. 4, 737 (1942). Brief note on sintered carbides used as cutting material.

(3182) Brazing Carbide Tips. C. Cleveland, *Hitchcock's Machine Tool Blue Book, 38,* No. 2 , 115-6 (1942). A simple method based on city gas is described.

(3183) Worn High-Speed Steel Tools Tipped With Carbide. J. S. Gillespie, *Iron Age, 150,* No. 22, 70-1 (1942). Procedure of tipping high-speed steel tools described may be followed for reclaiming when worn out and undersize.

(3184) **Producing 30 and 50 Caliber Cartridge Cases with Carbides.** E. Glen, *Machine Tool Blue Book, 38,* No. 9, 92-7 (1942). Changing over to carbides. General production sequence.

(3185) **Carbide Dies for Tube Drawing.** E. Glen, *Machine Tool Blue Book, 38,* No. 10, 167-8, 170-72 (1942). Use of dies and mandrels for drawing tube as small as 0.013 in. and as large as 3½ in. Advantages compared with steel and chrome varieties.

(3186) **Standard Drawing Dies for Small Ammunition.** E. Glen, *Metal Progress, 42,* No. 2, 229-232 (1942). Carbide dies by Carboloy, Inc., used; production sequence described; recommended die sizes given.

(3187) E. E. Hensoldt, *Hartmetallbohrkunde des Steinbruchs,* Verlag DAF, Berlin, 1942. The applications of cemented carbides in the mining field are treated.

(3188) **Carbide Tipped Reamers.** G. Herrick, *Tool Engr., 11,* No. 11, 74-75 (1942). Carbide tipped reamers will ream material much harder and tougher than with high-speed and carbon steel.

(3189) **Production of Hard Metal Alloys.** J. Hinnüber, *Stahl u. Eisen, 62,* No.52, 1083-91 (1942). A comparison of production and properties of cast and sintered tungsten carbide alloys in wire drawing dies is given. Addition of a second carbide for the improvement of properties is discussed. The use of boron carbide is mentioned.

(3190) **Machining Shells with Carbide Tools.** M. F. Judkins, *Metallurgia, 25,* No. 148, 121-122 (1942). The use of sintered carbide tools have greatly augmented the production rate of shell-making.

(3191) **Hard Metals.** H. Kalpers, *Bergbau, 55,* 215-22 (1942). A review is given with special emphasis on tools for mining.

(3192) **Twist Drills.** R. G. Leech, *Technique, 17,* No. 3, 173-7 (1942). Floating drill principle is described.

(3193) **Carbide Tool Crib System Used by Warner and Swasey.** T. E. Lloyd, *Iron Age, 150,* No. 26, 45-7 (1942). Centralized tool crib gives satisfactory service of tools.

(3194) **Carbide Drawing Dies.** J. R. Longwell, *Machine Tool Blue Book, 38,* No. 3, 123-4, 126, 128, 130 (1942). Wire-drawing die applications discussed in detail.

(3195) **Dry Versus Wet Grinding.** J. R. Longwell, *Machine Tool Blue Book, 38,* No. 9, 145-152 (1942). Advantages and disadvantages of dry and wet grinding of carbide tools.

(3196) **Use of Carbide Dies for Drawing Special Shapes.** J. R. Longwell, *Steel, 110,* No. 5, 80-82 (1942). Parts drawn to close tolerances now are being produced on a large scale by the carbide die drawing process. Importance of proper die maintenance is discussed.

(3197) **Carbide-Tipped Face Mills.** F. W. Lucht, *Am. Machinist, 86,* No. 3, 81-83 (1942). Cemented carbide cutters are described.

(3198) **Using Carbide on Large Machines.** F. W. Lucht, *Iron Age, 149,* No. 24, 60-1 (1942). Application of carbide tools is discussed.

(3199) **Carbide Tools on Large Machines.** F. W. Lucht, *Machine Tool Blue Book, 38,* No. 6, 129-136 (1942). Performance of carbide cutting tools is described.

(3200) **Five Methods Devised for Economical Tool Selection.** R. H. McCormick, *Metal Progress, 42,* No. 4, 736 (1942). Cemented carbide tools are covered in a brief note.

(3201) **Faster Cutting With Multi-Carbide Tools.** P. M. McKenna, *Metal Progress, 42,* No. 4, 736-7 (1942). Short note on improved method, using double and triple carbides containing tungsten carbide as major component.

(3202) **Tool Compositions of Cemented Hard Carbide, Their Properties and Industrial Application.** P. M. McKenna, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 40, pp. 454-69. Industrial applications - turning tools

for lathes and boring mills - threading tools - grinding - performance.

(3203) Carbide Tooling Usually Involves Decreased Forces on Work and Tools. F. H. Miller, *Steel, 110,* No. 8, 85 (1942). While the rate of metal removal and horse power have gone up, the tendency of the work to slip in the chuck has been cut in half.

(3204) Carbide Tools. F. H. Miller, *Tool & Die J., 7,* No. 12, 36 and 44 (1942). Description of how to determine cutting load.

(3205) Carbide Tools Increase Efficiency. P. H. Miller, *Wire and Wire Products, 17,* No. 8, 404-419 (1942). Table of constants for calculating the power requirement and tool loads for various materials.

(3206) High-Speed Milling with Carbides. E. G. Moffat, *Am. Machinist, 86,* No. 18, 933-6 (1942). Tool engineers at Watervliet Arsenal are using cutters with negative rake angles to speed the machining of steel forgings.

(3207) Hard Metals in Mining. E. Richter, *Metall u. Erz, 39,* 178-84 (1942). Mining tool applications of cemented carbides are described in detail.

(3208) No Shortage in Tungsten Carbide. W. G. Robbins, *Metal Progress, 41,* No. 5, 680 (1942). Ample supply of carbide for tools despite the war conditions claimed in brief note.

(3209) Standardized Tools Speed Production. W. G. Robbins, *Metal Progress, 42,* No. 4, 737-8 (1942). Brief note on role played by standardization of carbide tools in war effort.

(3210) Grinding of Cemented Carbide Tools. A. J. Schroeder, *Metallurgia, 26,* No. 153, 88-90 (1942). The technique is different from the grinding of cast carbides, and attention must be given to the grinding agent.

(3211) High Speed Steel Tips Cemented to Low Alloy Shanks. G. Shuler, *Iron Age, 149,* No. 16, 35-8 (1942). Author shows how vital tool steel is being conserved by using it in tip form, like cemented carbides.

(3212) Carbide Tools in War Work. F. N. Simons, *Tool & Die J., 8,* No. 7, 42-6 (1942). WC-tipped tools are described.

(3213) How to Select Efficient Cutting Tools. L. J. St. Clair, *Iron Age, 150,* No. 14, 60-67 (1942). Method is described with aid of a chart.

(3214) Carbide Tools for Shell Work. G. G. Thompson, *Iron Age, 149,* No. 20, 41-4 (1942). Introducing a negative rake on a carbide tipped lathe tool places a pure compressive load on the tool.

(3215) Get the Most from Carbide Tools. R. B. Weeks, *Am. Machinist, 86,* No. 5, 158-61 (1942). Simple rules for successful use of carbide tools.

(3216) Carbide Tools in Small Lot Production. W. White, *Machine Tool Blue Book, 38,* No. 5, 121-130 (1942). Performance of carbide cutting tools described.

(3217) Making Carbide Tipped Flat Boring Cutters. *Iron Age, 152,* No. 13, 54-5 (1943). Photographs and drawings illustrate the various steps in the manufacture of tools for a horizontal boring machine spindle.

(3218) Faster Carbide Tool Grinding. *Machine Tool Blue Book, 39,* No. 6, 169-70, 172 (1943). New tool grinding principle which may revolutionize grinding has been developed by Carboloy, Inc., and Edison General Electric Co.

(3219) Electronic Carbide Tool Brazing. *Machine Tool Blue Book, 39,* No. 6, 185-6, 188; *Ind. Heating, 10,* No. 9, 1308, 1310 (1943). Commercial availability of electronic induction equipment for attaching cemented carbide tool tips to shanks is described.

(3220) Grinding Carbide Form Tools. *Machine Tool Blue Book, 39,* No. 12, 223-4, 226 (1943). Review of methods of grinding at school for carbide supervisors operated by Carboloy Co.

(3221) How to Get the Most Out of Carbide Tools. *Machinery (London), 63,* 735 (1943). Examples of carbide tools in armament work.

(3222) How to Get the Most Out of Carbide Tools. *Machinery (N.Y.), 50,* No. 1, 163-4 (1943). Suggestions and current practice in armament work; high cutting speed.

(3223) New Carbide Tipped Tools. *Mech. World, 13,* No. 2934, 323-4 (1943). Details of new Firth Brown grade which can be used on ordinary machine tool with all advantages of hard metal tool.

(3224) Application of Vascoloy-Ramet. *Mech. World, 114,* No. 2957, 262-4 (1943). Information relating to TaC material for tools.

(3225) Development in Carbide-Tipped Tools. *Metallurgia, 27,* No. 161, 201-02 (1943). Availability of elements used in production of carbide-cutting materials.

(3226) How to Grind Carbide Form Tools. *Modern Machine Shop, 16,* No. 4, 156, 158, 160, 162 (1943). Diagrams presented which aid in better understanding of principles involved in actual grinding operations.

(3227) Development of Carbide Tipped Tools. *Sheet Metal Industries, 17,* No. 193, 863-4 (1943). Improvements made by Brown-Firth Research Laboratories.

(3228) How to Grind Carbide Form Tools. *Steel, 113,* No. 22, 101, 111 (1943). Principles involved in actual grinding operations on carbide tools are shown in illustrations.

(3229) Designing Carbide Tools. *Tool & Die J., 9,* No. 5, 94-7 (1943). Commercial information contained in film by Carboloy, Inc.

(3230) "Short Order" Form Tool Grinding. *Tool & Die J., 9,* No. 8, 131-4 (1943). Steps in grinding cemented carbide cutting tools are given through diagrams.

(3231) Brazing Carbide Tools. *Tool Engr., 12,* No. 6, 91-92 (1943). A new type tool grinding principle developed cooperatively by Carboloy Co. and Edison General Electric Co. saves skilled labor and grinding wheels.

(3232) Increase Punch Life. *Tool Engr., 12,* No. 11, 72-4 (1943). Production of W-carbide punch and die inserts for slotting and notching rotor and stator laminations in specially designed electrical motors.

(3233) Chip Control in Machining Steel with Carbides. E. Almdale, *Tool & Die J., 9,* No. 9, 105-9 (1943). Control is obtained by ground-in chip breakers.

(3234) Put Carbide Applications in Hands of Specialists. K. R. Beardslee, *Iron Age, 152,* No. 12, 62-4 (1943). Most effective use of carbide tools is discussed.

(3235) Cemented Carbide for the Wire Industry Die Development and Manufacture. H. Berry, *Wire Ind., 10,* No. 109, 33-5 (1943). Diamond limitations, German research, manufacture of cemented carbides, raw materials, and the mixture and grading of tungsten carbide with a cobalt bonding agent for the dies are discussed.

(3236) Hard Metal Lathe Tools. W. Dawihl and J. Hinnüber, *Werkstattstechnik-Betrieb, 37,* No. 11/12, 393-96 (1943). Fundamentals of the design of hard metal tool tips are given.

(3237) Tips on Increasing Life of Carbide Tipped Tools. J. S. Gillespie, *Can. Machinery, 54,* No. 3, 152 (1943). Reclaiming procedure is described.

(3238) Servicing Carbide Dies for Steel Shell Cases. E. Glen, *Can. Machinery, 54,* No. 10, 111-12 (1943). Discussion of service requirements.

(3239) Carbide Dies for Steel Shell Cases. E. Glen, *Metals & Alloys, 17,* No. 3, 536-8 (1943). Detailed description of operating characteristics of cemented carbide dies for manufacture of steel shell cases.

(3240) Production of Sintered Carbides and Their Application in Wire-Drawing Plants. J. Hinnüber, *Iron & Steel Inst., London, Bull. No. 87,* 160A (1943). Effects of composition and process of manufacturing on properties of sintered carbide dies. English abstract of article in *Stahl u. Eisen, 62,* 1083-91 (1942).

(3241) Use of Carbide Tools. J. Jaquet, *Rev. met., 40,* 225-32 (1943). Use and construction of carbide-tipped tools is described. Designs of different tools given.

(3242) Grinding Carbide Tools. W. L. Kennicott, *Steel, 113,* No. 10, 114, 154-56 (1943). Important factors in grinding which can greatly extend life of carbide-tipped tools used for cutting steels.

(3243) Extending Life of Steel-Cutting Carbide Tools. W. L. Kennicott, *Western Mach. & Steel World, 34,* No. 9, 308-09, 315 (1943). Methods of grinding steel-cutting carbide tools.

(3244) Centralized Tool Grinding. M. E. Knoll, *Machine Tool Blue Book, 39,* No. 4, 219-20, 22 (1943). Explanation of advantages of concentrating carbide tool grinding in one or more shop locations.

(3245) Using Shear Type Tools. F. W. Lucht, *Machine Tools Blue Book, 39,* No. 5, 199-200 (1943). Suggestions on carbide tooling are made.

(3246) Shear Type Tools and How to Use Them. F. W. Lucht, *Machinery (N.Y.), 49,* No. 7, 169-71 (1943). Successful use of cemented carbide shear type tools on cutting tough and scaly steel castings are described.

(3247) Roller Turner Tools. R. D. Mack, *Machine Tool Blue Book, 39,* No. 11, 217-8, 220, 224, 226; (1943). Carbide cutting tools discussed; Carboloy roller turner tool for Warner & Swasey turret lathes for turning to a 90° shoulder are cited.

(3248) Carbide Tools Tipped by Induction Brazing. P. Miller, *Am. Machinist, 87,* No. 21, 106-7 (1943). Step-by-step account of procedure illustrated.

(3249) Standard Carbide Tips for Special Tools. P. Miller, *Iron Age, 151,* No. 22, 63-4 (1943). Carboloy recommends substitution of standard tip styles and sizes for special tips in specific tools. Few examples illustrated.

(3250) High Speed in War Time Production Shop. G. Schlesinger, *Inst. Prod. Engrs., 22,* No. 4, 137-67 (1943). Increased output in workshop by introduction of high speed cutting tools and cemented carbides.

(3251) Carbide Gage Blocks. W. A. Scotten, *Tool Engr., 12,* No. 9, 76 (1943). Advantages in use of cemented carbides in master gage blocks described.

(3252) New Slants on Carbide Tools. G. G. Thompson, *Iron Age, 151,* No. 12, 59-63 (1943). Examples of typical failures of tools in shell machining operations.

(3253) Teaming Up Carbide Tools. G. G. Thompson, *Iron Age, 151,* No. 6, 62-3 (1943). Notes on carbide tool troubles and how to overcome them.

(3254) Douglas' Solution for Chrome-Moly Steel Milling. R. S. Turton, *Western Mach. & Steel World, 34,* No. 9, 289-92 (1943). Carbide-tipped tools are employed.

(3255) Shrouded Tungsten-Carbide Lathe Centers. *Engineering, 158,* No. 4096, 30 (1944). Developed by Carbideall Ltd. Differs from normal carbide center in not being solid core of material, but being formed as sheathing to conical steel insert carried in shank of center.

(3256) Powdered Brazing Alloys for Tipping Tools. *Ind. Heating, 11,* No. 11, 1931 (1944). Silver-copper and copper brazing of tungsten carbide cutting tool tips onto shanks is described.

(3257) Cemented Carbide File. *Iron Age, 153,* No. 13, 61 (1944). Kennametal, Inc., has developed a file of cemented carbide composition.

(3258) New Equipment. *Iron Age, 153,* No. 25, 73 (1944). Carbide Lathe Center manufactured by Wendt-Sonis Co.

(3259) Carbide Offset Tools With Composite Shank. *Iron Age, 154,* No. 2, 62 (1944). Unconventional method of making offset type carbide tools (Carboloy) discovered by Thompson Aircraft Products Co. to save machine hours and materials.

(3260) New Equipment – Small Tools and Gages. *Iron Age, 154,* No. 7, 81-84 (1944). A line of carbide insert thread milling cutters announced by Plan-O-Mill Corp. Carbide gage blocks announced by Jansson Gage Co. Diamond dresser tool production by Diamond Tool Co. Carbide thread gages made by Jansson Gage Co. Carbide gage blocks announced by Lincoln Park Industries, Inc.

(3261) Carbide Milling of Steel Features ASME Annual Meeting. *Iron Age, 154,* No. 24, 75-78, 156-161 (1944). Digest of several papers on carbides as presented at annual meeting ASME Nov. 27 - Dec. 1, 1944.

(3262) Use of Carbides for Press Work. *Machine Tool Blue Book, 40,* No. 5, 155-156, 158, 160, 162, 164, 166 (1944). Carbide's tremendously high abrasion resis-

tance and consequent ability to hold close limits and maintain high finish multiplies die life many times.

(3263) **The Art of Metal Cutting.** *Machine Tool Blue Book, 40,* No. 12, 199-210 (1944). Tantalum and titanium carbides as cutting materials are discussed.

(3264) **Files of Cemented Carbides.** *Metals & Alloys, 19,* No. 3, 728 (1944). Brief note on type of file made of high strength cemented carbide by Kennametal, Inc.

(3265) **100-Lb. Tungsten Carbide Die.** *Metals & Alloys, 20,* No. 1, 216 (1944). Carbide nib weighing over 100 lbs. used for economic deep drawing of sheet steel compressed gas storage tanks and manufactured by Carboloy Co.

(3266) **Grinding of Carbide Cutting Tools.** *Western Metals, 2,* No. 1, 15-7 (1944). 9 steps illustrating order and manner in which grinding operations are to be performed.

(3267) **Chip Control in Machining Steel with Carbides.** E. Almdale, *Can. Machinery, 55,* No. 2, 87, 160 (1944). Obtained by ground-in chip breakers.

(3268) **Carbide Tools for Automatics.** C. W. Blade, *Screw Machine Engineer, 5,* No. 4, 34-39 (1944). Governing conditions; cut-off tools; speeds and feeds; horsepower; grinding; coolants.

(3269) **Carbide Machining of Steels on Automatic Screw Machines.** C. W. Blade, *Tool & Die J., 10,* No. 9, 98-99, 126 (1944). Speeds and feeds, horsepower, toughing cuts, cut-off tools, grinding, coolants.

(3270) **Cushioning of Tipped Turning Tools.** C. E. Buote and R. Holden, *Iron Age, 154,* No. 3, 70-72 (1944). Tests conducted indicate that "cushioned" carbide tools with a copper shim under the tip have almost double the life between grinds as do tipped tools.

(3271) **D'Arcambal Solves Machinability Problems.** J. G. Cutton, *Metals Rev., 17,* No. 4, 9 (1944). Report on address by A. H. D'Arcambal on Feb. 21 before the New Jersey Chapter of A.S.M. on tools, especially sintered Ti, Ta and W-carbides.

(3272) **Carbide Milling of Steel.** H. A. Frommelt, *Iron Age, 153,* No. 25, 52-57 (1944). Originally presented at the Westinghouse Machine Tool Electrification Forum at Pittsburgh, Pa. Test data in chart form demonstrating the relation of lead or bevel angle and the number of pieces obtained per grind and the relationship between spindle horsepower and depth of cut, feed rate and width of cut.

(3273) **Applying Carbide Tools on Automatic Screw Machines.** O. Guttmann, *Iron Age, 153,* No. 18, 62-66 (1944). Some unconventional tool forms are illustrated.

(3274) **Carbide Drawing Dies.** J. Hinnüber, *Iron & Coal Trades Rev., 148,* No. 3972, 568 and 567 (1944). English abstract of Rept. No. 11 of Committee for wire manufacture of Verein deutscher Eisenhüttenleute, published in *Stahl u. Eisen, 62,* No. 52, 1083-91 (1942).

(3275) **Chip Control with Sintered Carbide-Tipped Tools.** M. F. Judkins, *Mech. Engineering, 66,* 201-02 (1944). Factors in chip formation, methods of controlling chips, ground-in chip groove, procedure for grinding grooves.

(3276) **Roughing with Carbides.** W. L. Kennicott, *Machine Tool Blue Book, 40,* No. 5, 277-278, 280, 282 (1944). Over-all efficiency of operation considering life of the tools, grinding time, etc., is better at lower speeds with positive angles and at higher speeds with negative angles.

(3277) **Grinding Steel-Cutting Carbide Tools.** W. L. Kennicott, *Machinery (N.Y.), 50,* No. 6, 158-61 (1944). Discussion of procedure for rough and finishing grinding. How to avoid cracks and checks.

(3278) **Use of Carbide Tools and Negative Rake Angles Factors in Increased Milling Speeds.** F. P. Kristufek, *Metals Rev., 17,* No. 12, 4 (1944). Report on talk by H. Ernst on Oct. 16 at meeting of New Jersey Chapter of A.S.M. on sintered carbide cutting tools.

(3279) **Cemented Carbides.** M. Littmann, *Automobile Engr., 34,* No. 446, 59-62 (1944). Recent German practice in design of hard metal tools are discussed. Two or more grades used in any one tool.

(3280) Milling Steel with Carbide Tipped Cutters. F. W. Lucht, *Iron Age, 153,* No. 11, 56-63 (1944). An analysis is made of the cutting action with carbide tips.

(3281) Milling Steel with Carbide Tipped Cutters. F. W. Lucht, *Mech. Eng., 66,* 192-198 (1944). Author compares fly milling with action of single point tool taking interrupted facing cut in lathe and shows why negative axial rake angles are desirable for maximum cutter life; analysis of all cutter angles is given; tabulation of machine and fixture requirements is included.

(3282) Roller Turner Tools. R. D. Mack, *Can. Machinery, 55,* No. 1, 134, 136, 150 (1944). Carboloy roller turner tool for Warner & Swasey turret lathes for turning to a 90° shoulder is described.

(3283) Development of Sintered Tungsten Carbide Drawing Dies. E. J. Sandford, *Sheet Metal Ind., 19,* No. 201, 129-34 (1944). Deals with raw material, preparation, presintering, hardness in comparison with steel and effect of contamination. Properties of W-carbide summarized.

(3284) Carbides: Something New in Taps. W. Scotten, *Tool Engr., 13,* No. 5, 101-102, 105 (1944). Wider utilization of carbides in taps foreseen.

(3285) Cushions for Tipped Tools. L. J. St. Clair, *Am. Machinist, 88,* No. 16, 83-85 (1944). Copper is introduced between high-speed steel tip and shank acts as a shock absorber.

(3286) Technique and Advantages of Employing Tungsten Carbide Inserted Dies. E. J. Swinn, *Sheet Metal Ind., 19,* 297-300 (1944). Considerations of practical applications of cemented carbides as inserts for wide variety of dies; design, production figures, maintenance.

(3287) Gooseneck Carbide Tools. G. G. Thompson, *Iron Age, 153,* No. 15, 68, 70 (1944). Author advocates use of carbide tools with gooseneck shanks to absorb the shock present on interrupted cuts.

(3288) History and Growth of Tungsten Carbide Die. A. R. Zapp, *Wire and Wire Products, 19,* No. 9, 543-6, 569-71 (1944). Early use in United States; evolution of basic die shape; die machinery developed, rough cored dies, applications.

(3289) Cemented Carbides. *Automobile Engr., 35,* No. 6, 252-3 (1945). American developments in the use of mechanically mounted blades. Clamping pressure to hold the carbide tip. Current design of heavy-duty tools.

(3290) Hard Cutting Tools and Their Shaping. *Engineer's Digest, 2,* No. 6, 270-73 (1945). Choice of grade, *i.e.*, proportions of constituents, for cutting tips varies according to qualities of the carbide.

(3291) Selecting Carbides for Milling. *Hitchcock's Machine Tool Blue Book, 41,* No. 4, 230, 232, 234, 236 (1945). Grinding, cutter design, feeds and speeds, vibration and chatter are discussed.

(3292) Carbide Milling of Steel. *Hitchcock's Machine Tool Blue Book, 41,* No. 11, 142-56 (1945). Examples and sketches of the milling operation are given.

(3293) Further Tests Reported on Carbide Hobs. *Iron Age, 155,* No. 11, 55-57 (1945). Operational tests conducted at Joshua Hendy Iron Works with a composite hob fitted with cemented carbide strip teeth.

(3294) Choice of Carbide Grades. *Iron Age, 155,* No. 17, 68 (1945). Crane Co., Chicago, selecting most suitable grade of carbide for each application.

(3295) Carboloy Inaugurates Training Program on Carbide Shell Tools. *Iron Age, 155,* No. 17, 100 (1945). To enable shell manufacturers to obtain better performance and increased service life from carbide tools.

(3296) 500,000,000 Stampings with Carbide Dies. *Iron Age, 156,* No. 9, 36, 96 (1945). Sintered carbide blanking and forming dies making use of inserts of Firth-Sterling Diecarb of a Rockwell hardness of 65-73 are showing excellent production performances.

(3297) Sectional Carbide Molds Facilitate Recutting. *Iron Age, 156,* No. 17, 50-51 (1945). It is reported that sectional carbide nibs have found successful application for compacting powders. The hardness of the carbide (Firthite) nibs and the performance of the sectional carbide nib molds in hydraulic press applications is much dependent on the metal powder to be compressed.

(3298) Carbide Cutters. *Machine Tool Blue Book, 41,* No. 6, 378 (1945). Outstanding increases in production are being obtained in the machining of most metals by the use of carbide cutters.

(3299) Sectional Carbide Nib Molds. *Mach. Tool Blue Book, 41,* No. 11, 199-200, 202, 204 (1945). Sectional nibs have produced from seven to ten times the number of compresses per grind possible with steel molds.

(3300) Factors in Application of Carbide Cutters. *Machinery (London), 66,* No. 1699, 482-84 (1945). Operation precautions, multiple cutter mounting, cutter location in relation to work are discussed.

(3301) Negative-Rake Turning and Boring. *Machinery (London), 66,* No. 1701, 529-35 (1945). Diagrams showing the shapes of the negative-rake tools are discussed.

(3302) Milling Cast Iron with Carbide Cutters. *Machinery (London), 67,* No. 1732, 689-97 (1945). Types of cast iron milled and scope of investigation. Results on tool life. Cost of milling power for milling.

(3303) Cutting Gears With Carbide-Tipped Hobs. *Machinery (N.Y.), 51,* No. 7, 176 (1945). Tests carried out at Joshua Hendy Iron Works discussed.

(3304) High-Speed Bearings Made from Cemented Carbide. *Machinery (N.Y.), 52,* No. 3, 148 (1945). Materials, lubrication, performance.

(3305) Tungsten Carbide Projectiles. *Modern Ind. Press, 7,* No. 5, 6-8 (1945). Armor-piercing shells with tungsten-carbide tips are described.

(3306) New Carbide Uses. *Modern Ind. , 10,* No. 5, 98 (1945). Cemented carbides used as bearings on such equipment as grinding machines and tips on steel shanks for aircraft industry.

(3307) Engineered Carbide Program Pays Dividends. *Product Eng. Management, 15,* No. 5, 72-6 (1945). The working of aluminum with hard metal tools at high speeds needs tools which are adapted to the working and to the special machines.

(3308) Thread Gaging with Cemented Carbides. *Product Eng. Management, 15,* No. 5, 88-89 (1945). Thread gages of hard metal are very wear-resistant and have a very long working service.

(3309) Negative Rake Cutting. *Sheet Metal Inds., 22,* No. 224, 2158-58 (1945). Advantages: increase in cutting speed, harder grades of carbides may be used, improved finish on work, elimination of cutting fluids, low temperature of work and tool after machining.

(3310) Sintered Carbide Die Inserts. *Steel, 117,* No. 17, 111, 126 (1945). Multiplies by 10 to 1000 the number of pieces produced per grind.

(3311) Cemented Carbide Dies. *Steel, 117,* No. 27, 72 (1945). Describes huge savings resulting from the use of cemented carbide nosing dies for artillery shell production. Based on a study of Carboloy Co.

(3312) Use of Carbides for Press Work. *Tool & Die J., 10,* No. 3, 97-100 (1945). The growing interest in using carbides is this material's tremendously high abrasion resistance and consequent ability to hold close limits and high finish over long runs.

(3313) DieCarb Blanking and Forming Dies. *Tool & Die J., 11,* No. 15, 112-114 (1945). Sintered carbide blanking and forming dies make use of inserts of Die-Carb.

(3314) Recommendation for High Speed Carbide Milling. *Western Mach. Steel World, 36,* No. 7, 306-07, 324, 327, 362, 364 (1945). General rules for choice of speed are given.

(3315) Sintered Carbide Blanking and Forming Dies. *Western Mach. Steel World, 36,* No. 11, 518-519 (1945). Multiply by 10 to 1000 number of pieces produced per grind.

(3316) New Method of Tipping Tools. *Western Metals, 3,* No. 2, 16 (1945). Brazing of the tool tips to the steel shanks is effected with silver-copper or copper brazing alloys.

(3317) Sintered Carbides Forming Dies. *Wire and Wire Prod., 20,* No. 9, 632-3 (1945). Firth-Sterling Steel Co. announces the production of sintered carbides blanking and forming dies that multiply by 10 to 100 the number of pieces produced per grind.

(3318) Tungsten Carbide Machine Parts. S. H. Brams, *Iron Age, 156,* No. 13, 55-57 (1945). Tungsten carbide now used as a metal for fabrication in addition to former use as a cutting tool. Results obtained by using W-carbide for machine parts at Carboloy Co. reported and new uses suggested.

(3319) Deep Drawing Dies of Cemented Carbide. W. J. Bratton, *Western Mach. Steel World, 36,* No. 9, 410-11 (1945). Carboloy dies have been used to produce two different types of cases for radio tubes.

(3320) Milling with Carbide Tools. F. M. Burt, *Modern Machine Shop, 18,* 134 ff. (1945). A few of the more important directive factors of high-speed milling operations by carbide tipped cutters discussed.

(3321) Brazing Carbide Tips. R. O. Catland, *Western Mach. Steel World, 36,* 486-492 (1945). Different methods employed for attaching cemented carbide tips to cutter bodies by brazing.

(3322) Turning Steel with Negative Rake Carbide Tools. C. Edgar, *Tool Die J., 11,* No. 8, 101-3 (1945). Description and sketches to show method of honing the cutting edge of a negative rake turning tool.

(3323) Milling Cast Iron with Carbides. M. Field and W. E. Bullock, *Mech. Eng., 67,* No. 10, 647-58 (1945). In a cutting speed versus tool life curve, there exists a maximum tool-life point toward the lower end of the speed range. This point probably occurs at lower speeds for harder cast irons. Machinability is related to metallurgical constituents which do not necessarily determine the average hardness.

(3324) Hints on Multiple Tool Steel Turning with Carbides on Tomorrow's Machines. R. Granzow, *Western Metals, 3,* No. 7, 36-37 (1945). Showing a chart based on the principle of using larger nose radii for heavier cuts and heavier feeds.

(3325) Negative-Rate Turning and Boring. G. M. Jalma, *Machinery (N. Y.), 51,* No. 5, 135-46 (1945). These tools possess desirable advantages and the reasons are described.

(3326) Carbide Cutters – Their Application and Selection. A. Jansson, *Tool Engineer, 14,* No. 6, 24-28 (1945). Contains a chart of grade selection of carbides for steel and a chart for cast and malleable iron and non-ferrous metals.

(3327) Mounting Carbide Cutters Mechanically. W. L. Kennicott, *Mech. Eng., 67,* 241-43, 254 (1945). A recent development in the use of cemented carbide cutting tools is adoption of solid carbide blades mechanically held in standard or special tools holders.

(3328) Cemented Carbide. R. D. Lazure, *Technique, 20,* No. 2, 77-81 (1945). Manufacture and use of carbide tools.

(3329) Progress Report on Carbide Hobs. A. J. Kroog and R. W. Righter, *Iron Age, 155,* No. 25, 67-69 (1945). With a modified hobbing machine, a steel pinion of 285 Brinell hardness can be cut at speeds of 200 ft. per min. with a 6 in. diameter hob. Tests made at the Joshua Hendy Iron Works on carbide hobs for cutting marine propulsion gear teeth.

(3330) Cemented Carbide Bearings. J. R. Longwell, *Am. Machinist, 89,* No. 14, 128-29 (1945). Carbide-to-carbide bearings have been subjected to same service as were steel ball bearings which they replaced for more than one year, with very little wear to show for it.

(3331) Carbides – The Key to High Production. J. R. Longwell, *Mill & Factory, 36,* No. 5, 92; No. 6, 102 (1945). I. Carbides as cutting tool metal; carbides as die metal; carbides as a wear-resistant metal. II. Uses and physical properties with chart.

(3332) Face-Milling Steel with Carbides. F. W. Lucht, *Mech. Eng., 67,* No. 3, 185-89 (1945). Best operating condition will be obtained if the face of the tooth first contacts the work at a distance equal to the feed per tooth back from the cutting edge.

(3333) Selecting Carbides for Milling. F. W. Lucht, *Tool Die J., 11,* No. 1, 98-100, 112-114 (1945). Grinding; cutter design; setup; feeds and speeds; vibration and chatter; grade selection; steel milling; cast and malleable iron.

(3334) Hand-Honing Carbide Tools. F. W. Lucht, *Western Metals, 2,* No. 1, 56-57 (1945). Hand-honing increases life of tool because scale and heavy chips are apt to make an extremely sharp cutting edge flake off.

(3335) Special Rake Angles Used for Sintered Carbide Tools. M. M. Martellotti, *Am. Machinist, 89,* No. 4, 122-25 (1945). Positive and negative rake angles may have opposite effects on the deflection of the work in milling thin sections.

(3336) Carbide Comes to Files. P. M. McKenna, *Western Mach. Steel World, 36,* No. 11, 504-6 (1945). Two types of filing surfaces are described.

(3337) Mechanics of the Metal Cutting Process. M. E. Merchant, *J. Applied Phys., 16,* 267-75 (1945). It is shown that a chipping operation which can be performed with hard metal tools only is the cutting with negative rake.

(3338) Carbide Milling of Steel. A. W. Meyer and F. R. Archibald, *Mech. Eng., 67,* No. 10, 659-67 (1945). Steels selected for test specimens. Conditions of tools after tests. Use of coolants. Hard steels. Conclusions.

(3339) Carbide Tipped Tools. W. A. M. Welles, *Am. Machinist, 89,* No. 4, 128 (1945). The use of copper cushions under the carbide tips has doubled the output between grinds.

(3340) Carbide Die Applications. A. R. Zapp, *Wire and Wire Products, 20,* No. 1, 38-41, 81-3 (1945). Outline of development and applications of W-carbide dies for nail mills and cold-heading operations.

(3341) Carbide Cutting Tools. *Am. Exporter (Ind.), 138,* No. 6, 24 (1946). Cemented carbides produced by powder metallurgy from carbides of W,Ti,Ta together with a binding material such as cobalt are molded into a variety of cutting tool shapes.

(3342) Carbide Teeth. *Am. Machinist, 90,* No. 10, 142 (1946). It is reported that a difficult metal sawing problem could be effectively solved by welding carbide teeth around the periphery of a circular saw.

(3343) Carboloy Dies Increase Die Life. *Iron Age, 157,* No. 9, 51 (1946). Gains in die life ranging from 10 to 1 to as high as 20 to 1 by use of cemented carbide dies used on a certain forming operation for stainless steel reported.

(3344) Tube Flaring Tool Carboloy-Tipped. *Iron Age, 157,* No. 9, 55 (1946). Carboloy lathe-center inserts used at Douglas Aircraft Co.

(3345) Carbide Milling Cutters Data Calculation Chart. *Machinery (N. Y.), 52,* No.8, 173-76 (1946). A chart which can be used to find cutter speed and horsepower.

(3346) Precision Balls Made of Tungsten Carbide. *Machinery (N. Y.), 53,* No.2, 189 (1946). Industrial Tectonics, Ann Arbor, Mich., have a new process for making W-carbide balls of high dimensional accuracy.

(3347) A Comparison of Various Grades of Cemented Carbide Tool Materials. *Materials and Methods, 24,* No. 2, 419 (1946). A table containing the information furnished by seven manufacturers is presented.

(3348) Carbide Laminating Dies Eliminate Burring. *Modern Ind. Press, 8,* No. 6, 8 (1946). Use of solid cemented carbides as punch and die material for the manufacture of stator laminations for electrical motors at the plant of O'Keefe and Merritt Mfg. Co. of Los Angeles resulted in a 50-fold increase in punch and die life.

(3349) Carbide Dies Receiving Wider Use. *Product Eng., 17,* No. 10, 139 (1946). Carbide dies are now being made for deep drawing of sheet metal by Carboloy Co., Inc.

(3350) Tungsten Carbide Tools. *Steel, 118,* No. 12, 106, 108 (1946). Recommendations and controlling factors pertaining to selection, application, cutting angle and speed.

(3351) Use and Servicing of Carbide Mandrels. *Steel, 119,* No. 18, 86, 88 (1946). Describes a few simple precautions to increase effectiveness of carbide mandrels in tube mills.

(3352) Wire-Drawing Dies. *Wire Industry, 13,* 505-506 (1946). Some of the intricate operations in the fabrication of suitable WC-dies.

(3353) Exploring Carbide Possibilities in Single-Point Tuning. J. F. Allen, *Tool Eng., 17,* No. 2, 27-35 (1946). Concrete beds absorb vibration; oil mist lubrication; transmission of cutting forces; strain gages improve tests.

(3354) Carbide Nibs for Powder Molds. W. Baker, *Machine Tool Blue Book, 42,* No. 11, 276, 280, 282 (1946). Major advantages and performance of preformed sectional sintered carbide die nibs originated by Firth Sterling Steel Co.

(3355) Forty Years of Progress in Cutting Tools. J. H. Barber, *Proc. Inst. Mech. Engrs., 154,* No. 1, 18-21 (1946). Improvements made since 1900 in cutting tools for lathes and other machine tools. Cemented carbides included in review.

(3356) One Billion Hits Predicted for Carbide Dies. G. A. Barth, *Am. Machinist, 90,* No. 15, 142-43 (1946). Two million razor blades were punched by carbide dies with no sign of wear.

(3357) Cemented Carbides Used for Other Purposes than Cutting Tools. K. R. Beardslee, *Machinery (N. Y.), 52,* No. 12, 150-56 (1946). Use of cemented carbides for deep-drawing dies, for punches, and in forge shop and forming.

(3358) Cemented Carbides Make Die Materials. B. C. Brosheer, *Am. Machinist, 90,* No. 19, 101-5 (1946). Roundup report covering latest experience with war developed application of carbides to dies and punches in number of plants.

(3359) Cutting Properties Improved by Titanium Added to Tungsten Carbide. W. J. Childs, *Metals Rev., 19,* No. 11, 2 (1946). Ti added to WC improves cutting properties. Report on talk by P. McKenna at September meeting of Eastern New York Chapter A. S. M.

(3360) Carbide Tool Misconceptions. H. Crump, *Machine Tool Blue Book, 42,* No. 9, 185-87 (1946). Discussion of the misconceptions concerning the use of carbide tools.

(3361) Selecting a Machine Tool for Carbide Tooling. T. C. Du Mond, *Materials and Methods, 24,* No. 2, 374-378 (1946). Advantages of carbide tooling, general machine considerations, specific requirements.

(3362) Machining Aluminum with Carbide Tools. C. Edgar, *Light Metal Age, 4,* No. 9, 8-10 (1946). With carbides, magnesium and aluminum can be machined at extremely high speeds. The tools should be hand honed or machine lapped.

(3363) Cushions for Carbides. A. W. Ehlers, *Tool Die J., 12,* No. 4, 80 (1946). Experimental developments through trial and error in a new approach to carbide-tipped tool design show promise of overcoming tip-shattering vibrations.

(3364) Speed and Feed Selection in Carbide Milling with Respect to Production, Cost and Accuracy. H. Ernst and M. Field, *Trans. Am. Soc. Mech. Engrs., 68,* 207-15 (1946). A comprehensive account is given of the recent studies, illustrated by test curves, and an analysis of milling costs.

(3365) Experiences with Carbide Tipped Tools. M. E. Feldstein, *Tool & Die J., 12,* No. 3, 82-87, 142-45 (1946). Discussion of essentials of good milling with carbide tipped cutters.

(3366) Carbide Die Applications, Present and Future. A. E. Glen, *Iron Age, 157,* No. 17, 51-54 (1946). Detailed review of previously concealed war time applications plus appraisal of future possibilities.

(3367) Carbide Die Use Increasing Rapidly. A. E. Glen, *Machine Tool Blue Book, 42,* No. 8, 187-90 (1946). The Carboloy stator laminating dies are made in two halves and clamped together so they can be taken apart for regrinding.

(3368) Carbide Mandrels – Their Care and Servicing. A. E. Glen, *Machine Tool Blue Book, 42,* No. 9, 197-210 (1946). Component parts of a Carboloy mandrel are a carbide nib mounted on a hardened steel stud and drawn up tight to a straight steel shank.

(3369) Metal Forming with Carbide Dies. A. E. Glen, *Materials & Methods, 24,* No. 2, 423 (1946). Engineering shop notes.

(3370) Progress in Drawing Tubing and Sheet Metal on Carbide Dies. A. E. Glen, *Modern Ind. Press, 8,* No. 3, 32, 42 (1946). The limit on tubing drawn on Carboloy dies has been raised from 3 in. diameter to more than 6 in.

(3371) Use of Carbide Mandrels. A. E. Glen, *Steel, 119,* No. 18, 86-87 (1946). A few simple precautions increase effective uses of carbide mandrels in tube mills.

(3372) Carbide Mills Aluminum Alloys. G. R. Gwynne, *Machinist (London), 90,* 1008-09 (1946). Describes war time experience gained at Douglas Aircraft Co.

(3373) Use of Cemented Carbides in Steel Processing. F. Hennig, *Steel Processing, 32,* No. 6, 379-82 (1946). Outstanding developments in direct and indirect applications described with explanation of typical examples and outline of advantage. Kennametal types of cemented carbides are especially emphasized.

(3374) Wedged and Clamped-Tip Carbide Tools. N. E. Hodge, *Machinery (London), 68,* No. 1751, 561-63 (1946). Milling cutters and single point tools are described.

(3375) Cushion Tips Extend Life of Negative Rake Turning Tools. W. C. Holloway, *Am. Machinist, 90,* No. 3, 108-09 (1946). Cut completed in one pass. The bearing fits blend well with the taper and need no grinding.

(3376) Cemented Carbide Dies. J. R. Longwell, *Steel, 119,* No. 23, 130-33 (1946). Industrial application and size ranges and limitations are given for cemented carbide dies and components.

(3377) Cutter Life as Affected by the Mounting of Cemented Carbide Blanks. F. W. Lucht, *Steel, 119,* No. 4, 80-83, 126 (1946). Article based on address delivered at the production engineering session, June 17, 1946 of A.S.M.E.

(3378) Carbide Drawing Die Practice. D. Mapes, *Machine Tool Blue Book, 42,* No. 11, 263-66, 268, 270 (1946). The reconditioning of the carbide nib of a sheet metal die is described.

(3379) Carbide Drawing Dies. D. Mapes, *Steel, 119,* No. 5, 84-86 (1946). Advantages of Carboloy cemented carbide dies used by Walter Kidde & Co., Inc., are described.

(3380) Removing Carbide Tips from Tool Shanks. R. G. Maurer, *Metal Progress, 49,* No. 3, 537 (1946). Solution of 80% nitric acid in 20% water at 80-90° C. (175 - 195° F.) is very useful for removing brazed carbide inserts from steel shanks. Precautions are necessary.

(3381) Hard Carbides Find Non-Cutting Uses. P. M. McKenna, *Am. Machinist, 90,* No. 17, 117-120 (1946). Table gives physical properties of carbides and steels. A number of current applications are discussed.

(3382) A Carbide-Tipped Gear Hob Design for Phenolic Laminates. R. Nauth, *Tool & Die J., 12,* No. 1, 84-86, 102-03 (1946). Description of a single hob tooth blank before and after grinding.

(3383) Cemented Carbides. C. Neal, *Can. Machinery, 57,* No. 7, 82-5 (1946). Development and production practice; milling and die applications; carbide tool grinding technique and recommended wheels; important factors in application of carbide cutters.

(3384) Hard Carbides. G. Oldham, *Mining Ind. (London), 227,* 772-774 (1946). A review of applications of metallic and non-metallic carbides.

(3385) Carbide Tooling at New York Naval Shipyard. C. A. Palmer and J. G. Kenney, *Mechanical Eng., 68,* No. 10, 879-84 (1946). The organization and the development of the program are described.

(3386) Forming of Hard Metal Dies. 50 Years of Tungsten Carbide. T. Richards, *Werkstatt u. Betrieb, 79,* 92-96 (1946). The composition of hard metal dies and their use are discussed.

(3387) Increasing Production with Carbide Tool Inserts. R. J. Rousseau, *Steel, 118,* No. 23, 92-93, 137, 140, 142 (1946). Use of carbide tipped tools by East Springfield Westinghouse plant ups tool life 1000%.

(3388) Top Surface Speed on Tough Alloys with Negative-Rake Carbide Tools. W. L. Sandham, *Am. Machinist, 90,* No. 14, 87-89, 112-16 (1946). Experimental project determines the tool design, depth of cut, speeds and feeds on a high-carbon, high-chromium alloy steel.

(3389) Tungsten Carbide Draw Dies. R. Saxton, *Metallurgia, 35,* No. 206, 68-69 (1946). Production of tungsten carbide dies by the powder metallurgy process; design and application details.

(3390) How the Russians Lap Carbides. Z. E. Scheelvoog, *Am. Machinist, 90,* No. 7, 138 (1946). Translation from an article in *Stanki i Instrument.* Use of carbide inserts for tools described.

(3391) Sectional Carbide Nibs. K. Stad, *Tool Engr., 15,* No. 6, 39 (1946). Performance details and advantageous features of preformed sectional sintered carbide nibs, originated by Firth Sterling Steel Co.

(3392) New Technique Cuts Milling Costs. K. Stad, *Tool Engr., 16,* No. 7, 41-42 (1946). Carbide milling cutters, even though used in old equipment, outperform high-speed steel cutters.

(3393) Tungsten Carbide Cutters. H. L. Wainwright, *Machinist (European Ed.), 90,* No. 27, 551-552 (1946). Tests of De Havilland Aircraft Co. showed that carbide cutters could be relapped with bakelite-bonded diamond impregnated wheels without notable wear of latter, with a better finish than had been obtained with Si carbide wheels.

(3394) All-Carbide Boring Bar. H. E. York, *Am. Machinist, 90,* No. 11, 115 (1946). Increased stiffness doubles usual length-to-bore ratio, halving time on valve guides.

(3395) Widening Useful Boring Range. H. E. York, *Machine Tool Blue Book, 42,* No. 9, 231-2, 234 (1946). Test data concerning use of boring bars made out of solid Carboloy cemented carbides.

(3396) Expanding Fields for Carbides. H. E. York, *Western Metal, 4,* No. 7, 60-61 (1946). Test data and results concerning possible applications of solid carbide boring bars, tests indicate stiffness of bars may widen useful range of boring.

(3397) Tools for Plastic Fabrication. *British Plastics, 19,* No. 221, 465-66 (1947). Tungsten carbide tipped saws and cutters are described.

(3398) Tungsten Carbide Bits — Key to Low Cost Drilling. *Eng. Mining J., 148,* No. 4, 102 (1947). Carbide type chisel-edge bits raised the speed to 12 in. per minute, Carboloy inserts from 25 to 30 in. per minute. Four-point bits developed by Carboloy Co. and Ingersoll Rand have drilled up to 250 feet into granite.

(3399) Chipless Cutting of Metals? *Ind. Diamond Rev., 7,* No. 77, 116 (1947). Chips are said to burn up entirely during cutting in which W carbides and extremely high surface speeds are used.

(3400) Maintenance of Sintered Carbide Dies. *Ind. Diamond Rev., 7,* No. 81, 238 (1947). Extracts from 1946 "Prolite Die Maintenance Manual" covering technological methods. Boring with diamond points, application of coarse and medium size diamond powders on soft and hard sticks.

(3401) Improved Production with Tungsten Carbide Dies. *Intern. Ind., 28,* 508 (1947). Advantages of tungsten carbide dies over tool steel described, for producing: (*1*) domestic hollow ware, (*2*) razor-blade blanks, (*3*) rotor and stator laminations, (*4*) brass boxes.

(3402) Cutting Flexible Glass with Carbide Saws. *Iron Age, 159,* No. 8, 56 (1947). The cutting is performed with a hand guided power saw at 20,940 rpm, without coolant, and using hand feed; the saw with carbide tips was used for 90 days without regrinding.

(3403) Principles of Design for Carbides. *Iron Age, 159,* No. 13, 56 (1947). Complex carbide shapes are illustrated for some unusual applications.

(3404) Attaching Carbide Parts by Threaded Inserts. *Iron Age, 159,* No. 16, 5-6 (1947). Process developed by Carboloy Co. enables attachment of carbide parts by embedding inserts in the carbide parts, which can be drilled.

(3405) Cemented Carbide Wire Straightening Dies. *Iron Age, 160,* No. 1, 54 (1947). The carbide dies were installed for 300 days without replacements; previously used dies lasted an average of two days.

(3406) Cemented Carbides Used for Dies and Punches. *Iron Age, 160,* No. 9, 64 (1947). Cemented carbides in high production dies and punches subject to high wear forces offer means of increasing die runs and boosting number of parts produced per grind.

(3407) Solid Carbide Boring Bars. *Iron Age, 160,* No. 17, 44-45 (1947). Discussion of boring holes in valve guides for aircraft engines and in cored wrist pin holes.

(3408) Solid Carbide Balls. *Machinery (N. Y.), 53,* No. 11, 204 (1947). Cemented carbide balls for use in check-valves made by Carboloy Co. in ten standard sizes.

(3409) Carbide Cutters Mill Locomotive Parts. *Machinist (London), 91,* 797-99 (1947). Gives details of negative rake milling at Midland & Scottish Railway Co.

(3410) Carbides for High Temperature Applications. *Materials and Methods, 26,* No. 6, 85-86 (1947). Kennametal cemented titanium carbide grade K 138 is characterized by light weight, high thermal conductivity, and high thermal shock resistance.

(3411) Method of Drilling and Tapping Carbides to Expand Their Applications. *Steel, 120,* No. 13, 94 (1947). Process in which machinable materials are solidly embedded in the carbide parts wherever these parts are to be tapped or drilled.

(3412) Detachable Bits. R. W. Adamson, *Mining Congr. J., 33,* No. 11, 38-40; No. 12, 46-48 (1947). Improvement in cutting quality of rock bits is important means of reducing drilling costs. Review of use of hard materials for rock bits. Tests in development of tungsten carbide insert bits.

(3413) Application of Cemented Carbides. K. R. Beardslee, *Machinery (London), 71,* No. 1828, 507-508 (1947). Wire and rod dies; deep-drawing dies; punches and dies for forge shop and foundry. Machine-tool construction.

(3414) Some Experiments with Tungsten Carbide Tipped Drill Steel. J. H. Bloemsma, R. Ramsay, and O. Deane, *J. Chem. Met. Mining Soc. S. Africa, 47,* 243-83 (1947). For normal stope drilling, the present cost of WC jumpers in relation to the drilling life is still much too high.

(3415) Carbide Makes Die Material. G. Brosheer, *Machinist (London), 90,* 1623-1627 (1947). Gives drawings and description of various carbide dies.

(3416) Cemented Carbides. V. Chiaverini, *Bol. Assoc. Brasil. Metals, 3,* No. 7, 333-59 (1947). Description of materials and cemented carbides used in cutting applications.

(3417) Application of Sintered Carbides. H. Eckersley, *Metal Ind. (London), 71,* No. 26, 521, 523 (1947). Typical lathe tools, milling cutters, rolls for flatting and forming round wire, press tools for blanking.

(3418) Use of Hard Metal for Tools. A. Fehse, *Werkstatt u. Betrieb, 80,* No. 3, 49-56 (1947). A review of several kinds of tools with hard metal bits and dies.

(3419) Production Methods Aid Carbide Control. H. L. Flynn, *Machinist (London), 91,* 101-04 (1947). Describes the carbide employing machining operations at Jack & Heintz, Inc.

(3420) How to Use Carbide Cutters for Milling. H. A. Frommelt, *Iron Age, 159,* No. 7, 44-45; *160,* No. 2; 66-67 (1947). The general concept of carbide milling is discussed with special emphasis placed on the cutter angles and the power requirement.

(3421) Carbide Sheet Metal Dies. E. Glen, *Steel Processing, 33,* No. 9, 618-21 (1947). The author discusses the use of sintered carbides in progressive dies, draw dies and blanking dies.

(3422) Detachable Carbide Percussive Bits. H. M. Griffiths, *Mining J., 228,* 365, 382 (1947). Refers to B.I.O.S. Report No. 654. Swedes launched campaign in South Africa with one piece drill rods having carbide blades. The Riploy carbide bits, its advantages; grinding of bits.

(3423) Tungsten Carbides for Rock Bits. P. M. McKenna, *Mining Congr. J., 33,* No. 12, 49-50 (1947). Supplementing the article by R. W. Adamson presents author's review of problem of insert attachment and bit design.

(3424) Hard Metal Edges for Rock Drills. E. Ryd, *Jernkonterets Ann., 131,* No. 9, 373-424 (1947). Describes the forms, uses, and tests of different kinds of rock drills.

(3425) Tungsten Carbide Rolls. E. C. Slick and R. E. White, *Iron Age, 160,* No. 15, 74-75 (1947). Increases in roll life of up to 50 times of that of steel and improved finish are among advantages resulting from use of carbide rolls for wire flattening.

(3426) Cutting Angles. Studiengesellschaft Hartmetall. F. D. Rept. No. 3739/47 (1947). Determination of optimum cutting angles was reported in 1936.

(3427) Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3748/47 (1947). Carbide tips sintered either in the oxide tube furnace or in the carbide tube furnace gave equivalent drilling performance in experiments reported in 1936.

(3428) Carbide Dies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3754/47 (1947). Carbide dies for drawing copper should have a short neck and be toughened at top and bottom by zones of higher cobalt content, as reported in 1932. The quality of Krupp dies improved between 1929 and 1933, as shown by tests for porosity conducted in 1935.

(3429) Carbide Balls. Studiengesellschaft Hartmetall. F. D. Rept. No. 3761/47 (1947). According to this report of 1937, carbide balls worked from solid cylinders cracked with 50% rejects. The reject rate was reduced to 1% by pressing with slightly concave graphite inserts from top to bottom. Convex inserts were also useful, though less so than the concave ones.

(3430) Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3764/47 (1947). Modified shape of carbide tip for grinding shells is described in this report of 1937.

(3431) Tungsten Carbide-Free Cutting Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3780/47 (1947). In 1938, alumina cutting tools of excellent quality were made with admixtures of 20% iron (as oxide) and 4% porcelain flour, sintered at 1550° C. (2820° F.); a mixture of 80% (94% alumina, 5% powdered marble, 1% quartz) and 20% iron (as oxide) sintered at 1500° C. (2730° F.); 85% of the mixture as before, 10% iron, 5% nickel. Alumina alone required a sintering temperature of minimum 1750° C. (3180° F.). These tips were superior to high-speed steel for cutting insulating material.

(3432) Carbide Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3799/47 (1947). According to this report of 1939, carbide-tipped shafts of "Presszellstoffe" can be used for turning insulating material and perhaps also light metals.

(3433) Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3810/47 (1947). In this report of 1939 it is shown that WC-TiC tips containing up to 15% TaC give improved performance on mild steel at low speeds. TaC-containing tips also have a higher oxidation resistance.

(3434) Carbide Drill Bits. Studiengesellschaft Hartmetall. F. D. Rept. No. 3827/47 (1947). Metallographic testing of faulty WC drill bits was conducted in 1940.

(3435) Drawing Dies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3847/47 (1947). In this report of 1940 a patent application of Heraeus-Vacuumschmelze for an 80/20 WC-Mo_2C drawing die was shown to be valueless. The addition of 5% cobalt gave a drawing die of the usual quality.

(3436) Patents for Hard Metals Armorplating. Studiengesellschaft Hartmetall. F. D. Rept. No. 3848/47 (1947). Discussions in 1940 with Krupp are reported.

(3437) Carbides for Machining Steel. Studiengesellschaft Hartmetall. F. D. Rept. No. 3851/47 (1947). Steel shafts heated to 700-900° C. (1290 - 1650° F.) were machined with S–1 hard metal tips which gave out after 1 min. Boride tips, however, (composition not given in this report of 1940) were found to be useful for machining steel at 800° C. (1470° F.).

(3438) Sintered Hard Metal for Armorplate. Studiengesellschaft Hartmetall. F. D. Rept. No. 3855/47 (1947). Of possible use for making large armored plates was the following procedure developed in 1940: Reground sintered hard metal was moistened with a mixture of water and methanol, tamped into large plastic molds, sintered and impregnated with cobalt.

(3439) Armored Plating. Studiengesellschaft Hartmetall. F. D. Rept. No. 3860/47 (1947). A secret document of 1941 listing proposed methods of making armored plating from hard metal.

(3440) Fracture of Carbide Die. Studiengesellschaft Hartmetall. F. D. Rept. No. 3861/47 (1947). The fracture of a carbide die was attributed in this report of 1941 to swelling caused by formation of the δ-phase.

(3441) Use of Carbide Tips. Studiengesellschaft Hartmetall. F. D. Rept. No. 3889/47 (1947). Organization and instructions for the use of carbide tips in munitions factories, dating back to 1941.

(3442) Carbide Tips for Machining. Studiengesellschaft Hartmetall. F. D. Rept. No. 3890/47 (1947). Results obtained by 1941 in machining shell cases and rifle bores.

(3443) Carbide Drawing Dies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3916/47 (1947). Porosity in carbide drawing dies was due to the formation of a lamellar β-phase. The porosity is ascribed also to carbon absorption by the β-phase and grain growth of the α-phase.

(3444) Carbide Tipped Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3924/47 (1947). Vibration and temperature measurements on carbide tipped tools for machining steel were made in 1942. The cutting temperature was approximately 700° C. (1290° F.) in all cases.

(3445) Carbide Drawing Dies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3936/47 (1947). Discussions regarding the manufacture of carbide drawing dies at Heraeus-Vacuumschmelze, dating back to 1943.

(3446) Cores of Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 4003/47 (1947). Microstructure of carbide ammunition cores of 1941.

(3447) Tungsten Carbide Promises Faster, Cheaper Drilling. R. G. Sullivan, *Eng. & Mining J., 148,* No. 3, 57-58 (1947). Tests made with 2-point and 4-point drill bits with cutting edges of W-carbide indicate that they surpass standard detachable bits in drilling speed and in use of life.

(3448) Percussive Rock Drilling with W Carbide Bits. W. W. Varvill, *Mine and Quarry Eng., 13,* No. 2, 37-44 (1947). Data and development of hard metal bits in Germany.

(3449) Tungsten Carbide-Tipped Percussion Drill Bits. E. M. Wilson, B.I.O.S. Final Rept. No. 1614 (1947). Coal cutter picks in Germany were carbide-tipped, as wear resistance to material of varying hardness was considered of primary importance.

(3450) Selection of Cemented Carbides for Wire Drawing Dies. I. A. Yukhvets, *Stal, 7,* No. 8, 737-41 (1947). Experimental study of optimum cobalt content for WC dies destined for the drawing of fine, common, coarse, and large wire. Cemented carbide compositions studied: WC + 3, 6, 10, and 13% Co. Lubricant used in experiments: powdered soap.

(3451) Tungsten Carbide. A. R. Zapp, *Wire and Wire Products, 22,* No. 8, 591, 612 (1947). Recent developments and applications discussed, including punches and dies for higher temperatures, cut-off knives in nail industry, rolls for edging sheets.

(3452) Sharpening of Cemented Carbide Tools by the Electro-Erosion Spark Discharge Process. B. N. Zolotykh, *Stanki i Instrument, 18,* No. 3, 23-24 (1947). An experimental study of the most favorable conditions for grinding.

(3453) Carbide Tool Routs Fiberglas. *Machinist (London), 92,* 189-90 (1948). Fluted solid carbide tools and automatic dust removal solved this problem.

(3454) Learning to Use Carbides. *Machinist (London), 92,* 361-64 (1948). One-week courses in the use of carbide tools are held by A. C. Wickman, Ltd.

(3455) Tungsten Carbide in South Africa. *Metal Ind. (London), 73,* 174 (1948). The erection of a factory for the production of rock drills is reported.

(3456) Drill Jig Bushings. *Steel, 122,* No. 16, 124 (1948). Carbide inserted drill jig bushings are made by W. F. Meyers Co., have a W carbide insert at the point of wear, thus insuring longer life and greater accuracy.

(3457) Carbide Die Construction. *Steel, 123,* No. 23, 115, 157 (1948). Diamond boring instead of diamond grinding is used on dies with one or more radii.

(3458) Carbide Cutting Tools. *Western Machinery Steel World, 39,* No. 1, 82 (1948). Charts presented for selection of starting grades of carbides for milling operations.

(3459) German Tungsten Carbide Drawing Dies. J. Baker, E. L. Francis, T. E. Alker and S. Waite, B.I.O.S. Final Rept. No. 1711, 1948, 80 pp.; *Met. Powd. Rept., 2,* No. 9, 135 (1948). Report of Krupp's methods: pressing of die pellets, hot-pressing, presintering, calibrating, design and manufacture of dies. Wallram: Hand polishing by a self-contained automatic collet head. Die making practices at Felten & Guilleaume, Klöckner, A. W. Schewe and Ossenburg are also discussed.

(3460) Carbide Tools in Finland. H. Branders, *Machinist (London), 92,* 1054-1056 (1948). Attention is paid to the tool finish, for which detailed instructions are provided.

(3461) Modern Uses of Hard Metals. H. Burden, *Metallurgia, 38,* No. 223, 27-33 (1948). Classification of hard metals and discussion of hard metal cutting tools and forming tools.

(3462) Carbides Boost Dairy Equipment Production at International Harvester. L. W. Court, *Modern Machine Shop, 21,* No. 2, 190, 92, 94, 96 (1948). Use of cemented carbide tools is described.

(3463) Large Cemented Carbide Sections Gain Wide Industrial Use. H. Crump, *Steel, 123,* No. 13, 103, 106 (1948). New techniques and modified metal mixtures show material to be economically sound for tool tips, boring bars, broaches and other applications.

(3464) Roll Turning with Carbide Tools. F. R. Dinger, *Iron Steel Eng., 25,* No. 9, 66-69 (1948). The advent of new machine tools and the continued progress in tool engineering and application of machining rolls are described.

(3465) Tungsten Carbide in Mining. J. A. Drain, *Can. Mining J., 69,* No. 4, 90 (1948). Notes on the development of carbide cutting bits for rock drills and coal cutters.

(3466) Cemented Carbide Milling Cutters. H. Eckersley, *Machinery (London), 72,* No. 1842, 211-14 (1948). Nomographs for feed rates corresponding to various metal removal capacities and areas of cut.

(3467) Threading at 2000 RPM with Carbide Tipped Chasers. S. T. Hicks, *Iron Age, 162,* No. 22, 80-82 (1948). Carbide chasers are described in connection with turret lathes.

(3468) Trepan Boring of Deep Holes. W. Iwascheff and E. Schönberg, *Machinery (London), 73,* No. 1882, 701-2 (1948). Describes experiments with hard metals and cemented carbide cutters.

(3469) Wet Turning with Hard Metal. W. Iwascheff, *Werkstatt u. Betrieb, 91,* No. 9, 252-55 (1948). A report on the method and output.

(3470) Economy on Boring of Rocks with Hard Metals. H. Jeschke, *Z. Erzbergbau Metallhüttenwesen, 1,* 168-76 (1948). The properties of hard metal inserts for tools for boring rocks are discussed; relation between speed of the tool and the hardness of the rock; devices for grinding.

(3471) Increase of Output by Sintered Hard Metals. H. Kalpers, *Industrie u. Technik, 3,* No. 6, 124-28 (1948). Development of sintered hard metals to facilitate chip formation; properties of sintered hard metals; tools with hard metal inserts; working with hard metal tools.

(3472) Sintered Hard Metal as Wear Resistant Material. R. Kieffer and F. Benesovsky, *Industrie u. Technik, 3,* No. 12, 251-57 (1948). The use of cemented carbides for wear and corrosion resistant purposes is described.

(3473) Carbide Dies Cut Laminations. R. Le Grand, *Machinist (London), 91,* 1248-52 (1948). Describes experiences with progressive dies at Lincoln Park Industries, Inc.

(3474) Carbide Inserts for Single Point Tools. T. E. Lloyd, *Iron Age, 161,* No. 16, 82-83 (1948). Development of new technique in holding carbide cutting tools in single point tool-holders has resulted in considerable experimentation.

(3475) Carbide Drills. F. W. Lucht, *Iron Age, 161,* No. 25, 88-90 (1948). Three types of carbide drills are discussed; also drill design, sharpening techniques and machines; cutting speeds and feeds.

(3476) Practical Application and Mill Practice with Carbide Dies. E. T. Miller, *Wire and Wire Products, 23,* No. 10, 910-13 (1948). Contrasts previous die practices with modern methods of wire drawing using carbide dies.

(3477) Carbides Speed Copper Machining. C. R. Morgan, *Machinist (London), 92,* 1428-29 (1948). Copper machining necessitates changes in drill and threading tool design.

(3478) Application of Carbides to Press Tools. A. L. Papworth, *Machinist (London), 92,* 455-59 (1948). An illustrated article of A. C. Wickman, Ltd.

(3479) Hard Metal Tools for Turning Light Metal. A. Pernollet and R. Schweykart, *Rev. aluminium, 25,* 343-52 (1948). The form of the edges of the tools and the kind of cutting are discussed.

(3480) Carbide Inserts. A. L. Pranses, *Machinist (London), 92,* 847 (1948). Standard carbide tool blanks are inserted to minimize die wear.

(3481) Planing Cast Iron with Carbide Tool. G. J. Raible, *Machinery (London), 73,* No. 1881, 675-76 (1948). Discussion of clamped-on carbide-tipped tools.

(3482) Tungsten Carbide Blanking Dies. E. J. Reitler and C. R. Harmon, *Tool Engineer, 20,* No. 2, 47-50 (1948). Carbide dies can be operated at higher speeds than steel dies.

(3483) Fitting Carbides to Small Tools. J. Safhill, *Machinist (London), 91,* 1477 (1948). Carbide tools, used for machining small telephone parts, are described.

(3484) Carbide Die Maintenance. R. Saxton, *Metallurgia, 38,* No. 228, 314-16 (1948). The production of sintered carbide dies and their maintenance in a serviceable condition are described.

(3485) Economy Factors in Carbide Milling. A. O. Schmidt, *Iron Age, 161,* No. 22, 72-77 (1948). The results of extensive tests on three types of carbide face mills stress the importance of such factors as the work rigidity, cutter feeds and speeds, work piece hardness, carbide grade and machine load in improving the cutting efficiency.

(3486) How to Machine Vitallium with Carbide Cutters. J. Sdano, *Machinist (London), 92,* 1726-28 (1948). Gives test results on milling and drilling of gas turbine blades at Allis-Chalmers Manufacturing Co.

(3487) Percussive Drilling with Hard Metal. D. H. Shute, *Met. Powd. Rept., 3,* No. 2, 18-19 (1948). A review is given of the problem of equipping percussion drills with satisfactory tungsten carbide bits that can withstand the impact.

(3488) German Manufacture of Tungsten Carbide. L. Wachtel and W. T. Wilson, B.I.O.S. Final Rept. 1727, 1948, 16 pp.; *Met. Powd. Rept., 2,* No. 9, 135 (1948). German coal cutter picks were carbide-tipped during the war as wear resistant materials of varying hardness were considered of primary importance.

(3489) Tests in U.S.A. with Boring Chisels of Hard Metals. H. Wöhlbier, *Z. Erzbergbau Metallhüttenwesen, 1,* 273-4 (1948). Results of tests on boring chisels with hard metal edges are given.

(3490) F. L. Woodcock, *Design of Metal Cutting Tools.* McGraw-Hill, New York, 1948, 400 pp. Carbides, carbide tools and carbide tipping are dealt with.

(3491) Planing with Carbides. *Am. Machinist, 93,* No. 2, 265, 267 (1949). Contains tables for carbide grades, speeds and horsepower.

(3492) Manufacture of Carbide Dies. *Machinery (N. Y.), 55,* No. 6, 170-1 (1949). Informative article describes the practice of Allegheny Ludlum Steel Corp. and contains a table of shrinkage allowances for carbide dies in tool-steel casings.

(3493) Higher Output with Carbide Lamination Dies. *Machinery (N. Y.), 55,* No. 7, 171-73 (1949). A progressive carbide die is used to produce rotor and stator laminations for electric shaver.

(3494) Cemented Carbide Tools. *Machinery's Yellow-Back Ser. No. 6,* The Machinery Publishing Co., Ltd., London, 1949. Carbides and bonding agents used for metal cutting; the design, care and maintenance of tipped tools.

(3495) Carbide Control Cuts Inventory Cost. *Machinist (London), 93,* 537-40 (1949). Discusses the advantages of coordinating all carbide tooling operations at Cleveland Automatic Machine Co.

(3496) Carbide Die Construction. *Steel Processing, 35,* No. 1, 21-3 (1949). Practices generally adopted in manufacture and construction of carbide dies; discussion is based on building simple draw die for first draw operation on deep draw job, using 1/16-in. cold rolled material having I.D. of 4 in.; four steps discussed include carbide and proper support, diamond boring, grinding and lapping.

(3497) Tungsten Carbide Bits Used for Hard Rock. J. M. Antill, *Chem. Eng. Mining Rev., 41,* No. 12, 440-43 (1949). Thousands of feet of extremely hard and dense rock are drilled by tungsten carbide tipped bits.

(3498) Carbide Cutting Tools: How to Make and Use Them. W. Baker and J. S. Kozacka, Chicago, Ill.: American Technical Society; Kingston Hill Surrey: The Technical Press, Ltd. (1949). The production and the use of carbide tipped cutting tools are discussed.

(3499) Tips of Hard Metals for Tools. C. Ballhausen, *Die Technik, 4,* 79 (1949). The construction of hard metal tools and dies is described.

(3500) Tungsten Carbide Bits for Blockholing at Ajo. A. T. Barr, *Mining Eng., 1,* No. 7, 28-9 (1949). Tungsten carbide bits were more economical than steel bits by reason of their much longer wear and fewer sharpenings required.

(3501) Centralized Control of Carbide Tooling Pays Dividends. B. Blacker, *Machinery (N. Y.), 56,* No. 1, 170-76 (1949). How coordinated tool control problem, developed by the Carboloy Co., is being applied by New Britain Machine Co.; standardized tools used up to 95%; centralized grinding assures high quality of tools; rigid inspection and close inventory controls; reduction of new tooling costs by 1/3 reported together with several other advantages.

(3502) Applicability of Ceramics and Ceramals as Turbine Blade Material. A. R. Bobrowsky, *Trans. Am. Soc. Mech. Engrs., 71,* No. 6, 621-29 (1949). Tests on titanium carbide base compositions are described for high temperature applications.

(3503) Application of Tungsten Carbide Cutting Tools. C. Eatough and H. Eckersley, *J. Inst. Prod. Eng., 28,* 394-422 (1949). The paper was presented to the Coventry Section of the Institution in October, 1948.

(3504) Rock Drilling at Mansbacher Bleiberg. H. Fritsche, *Metall u. Erz, 2,* 299-302 (1949). Description of turning with hard metal crowns of rock drills.

(3505) When and How to Use Carbide Insert Cutting Tools. J. S. Gillespie, *Iron Age, 163,* No. 19, 84-89 (1949). How tools and tool holders should be designed, applied, and maintained.

(3506) Increased Use of Hard Carbides for Wear Resistance. J. S. Gillespie, *Metal Progress, 56,* 523-26 (1949). An illustrated article showing carbide-lined barrels for forming abrasive wheels; carbide burrs.

(3507) Carbide Dies Set Production Records. A. E. Glen, *Machinist (London), 93,* 11-14 (1949). Describes a number of case histories on the use of Carboloy dies for sheet metal press work.

(3508) Fundamental Principles of Drawing Dies. C. W. Hinman, *Machine Tool Blue Book, 45,* No. 4, 115-16 (1949). A step-by-step description of the drawing of ten-gallon stock-pots.

(3509) New Uses for Hard Metal. J. Hinnüber, *Maschinenmarkt, 55,* No. 81, 38-40 (1949). A review.

(3510) Turning with Negative-Rake Tools. R. Huber, *Oesterr. Maschinenmarkt u. Elektrowirt., 4,* 64-67 (1949). Discussion of advantages of hard metal tools with negative rake.

(3511) Brazed *vs.* Mechanical Attachment of Carbide Tools Favor Latter. H. A. Johnson, *Metals Rev., 22,* No. 2, 9 (1949). Tools designed to have the hard carbide tool blanks attached by mechanical means instead of by brazing have much greater scope.

(3512) Economy in the Working of Sandblast Units. H. Kalpers, *Metalloberfläche, 3,* 67-70 (1949). Advantages of nozzles made from hard metal are discussed.

(3513) Carbide Tooling at New York Naval Shipyard. J. G. Kenney, *Modern Machine Shop, 22,* No. 4, 110-14 (1949). A program for coordinated carbide control enabled the shipyard to speed up production as much as 400%.

(3514) Tungsten Carbide Tipped Tools. F. S. Lewis, *Post Office Elec. Engrs. J., 41,* 213-5 (1949). Outline is given of manufacturing processes involved in production of tungsten carbide tipped tools, and of special grinding technique employed; improved performance obtained as compared with that for normal high speed steel tools.

(3515) Milling Cutters. K. Lippacher, *Werkstatt u. Betrieb, 82,* No. 2, 49-50 (1949). Impact milling by means of carbide cutting tools; process can be employed for machining metals and plastics at extremely high cutting speeds and feeds; tough structural steels can be milled at speeds as high as those employed on light metals; test results reported by Krupp for impact milling of 0.45% carbon steel with tensile strength of 38 to 44.5 tsi; schematic diagrams, table.

(3516) What are Carbides Good For? R. D. Mack, *Western Machinery & Steel World, 40,* No. 1, 82-5, 100 (1949). Properties of carbides and characteristics of Carboloy and its superior hardness are discussed; uses of carbide metals for cutting tools, dies and as wear resistant metals are described; wide field of application in textile and construction industries and in consumer goods production is stressed.

(3517) Tungsten Carbide Tooling for Cold Heading. W. E. Montgomery, W. Leigh, and W. H. Phillips, *Steel Processing, 35,* No. 8, 407-12, 531-36, 563 (1949). Headers and the relative position of the carbide tools in the header are described.

(3518) Rapid Machining with Tools Having Negative Rake. N. D. Morozov, *Stanki i Instrument, 20,* No. 6, 12-14 (1949). The importance of the negative rake on cemented carbide tools is explained.

(3519) Westinghouse Reports on Carbide Dies. G. P. Muir, *Tool Eng., 22,* No. 4, 17-20 (1949). The production of electric motor laminations is described.

(3520) Carbide Blocks Spin Tube Ends. H. Peppercorn, *Machinist (London), 93,* 277 (1949). Improved spinnings are made by Kennametal cemented titanium carbide grade K 138A.

(3521) Drilling with Hard Metal in Underground Mine "Stein V". W. Pohl, *Metall u. Erz, 2,* 88-94 (1949). Article deals with percussion drilling with hard metal.

(3522) Stepped or In-Line Carbide Cutters? J. S. Rainey, *Machinist (London), 93,* 952-54 (1949). Apart from exceptional cases, preference is given to the in-line cutters.

(3523) What Economies Can You Expect from the Use of Solid Carbide Insert Cutting Tools? W. F. Schleicher, *Machine & Tool Blue Book, 45,* No. 10, 85-88, 92-96 (1949). Typical applications of turning with different kinds of hard metal tips are given.

(3524) Development of Rotary Drilling in the Investigation of Firedamp. P. Schulz and K. Troesken, *Glückauf, 85,* No. 7, 110-116 (1949). The tests with different forms of crown bits from cemented carbide are discussed.

(3525) Hard, Tough Alloys Can Be Machined. F. B. Sills, *Am. Machinist, 93,* No. 24, 84-85 (1949). Ordinary turning, boring and drilling operations with cemented carbide tools can replace costly grinding for heavy stock removal on high-temperature alloys.

(3526) Life Tests Help to Choose Die Materials. J. R. Taylor and A. T. Hamill, *Am. Machinist, 93,* No. 14, 116-8 (1949). Investigations reported by Westinghouse Electrical Corp. on tool steels, cast refractory alloys, and cemented tungsten carbides.

(3527) Percussion Rock Drilling with Tungsten Carbide Tipped Bits. E. J. Wells, *Chem. Eng. Mining Rev., 41,* No. 4, 135-41 (1949). Preference given to detachable bits, which permit use of expensive high grade alloys for steel bodies, facilitate factory manufacture, and allow miner to select his own length of steel; brazing of tungsten carbide inserts directly into desired length of drill rod is also common.

(3528) Dry Drilling with Hard Metal Cutters and Screw Bits. K. Wild, *Z. Erzbergbau u. Metallhüttenwesen, 11,* No. 5, 134-8 (1949). Advantages and economy of hard metal bits; drilling results; wear of bits.

(3529) Forming of Welded Surface Layers by Machining. J. Witthoff and F. Hettich, *Werkstatt-Betrieb, 82,* 202-04 (1949). The use of cemented carbide tools for this purpose is described.

(3530) Development of the Percussion Drilling with Hard Metal in the Ruhr Coal District. G. Zeppernik, *Glückauf, 85,* No. 21, 380-83 (1949). Diminishing of the working power by the percussion drilling is discussed.

C. Diamond impregnated and abrasive materials

(3531) New Perspective for Alloying. K. Friedrich, *Metallurgie, 7,* 97-9 (1910). A suggestion is advanced for making abrasive products by stirring hard particles of glass, quartz, or carborundum into low-melting alloys.

(3532) Diamonds and Widia. F. K. Böck, *Maschinenkonstrukteur, 64,* 220-23 (1931). Author considers that for many purposes diamonds are superior to "Widia," and the costs for small work therefore are not prohibitive.

(3533) Preparation of Boron and Boron Compounds. E. Podszus, *Z. anorg. allgem. Chem., 211,* 41-48 (1933). The production and properties of boron carbide are treated. A compound corresponding to the formula B_6C was found to scratch diamond (according to F. Laves, *Nachr. Göttinger Ges., mathem.-physik Klasse, 1,* 57-58 (1934), this compound was established at B_4C).

(3534) Diamond-Impregnated Carboloy. G. F. Taylor, *Gen. Elec. Rev., 37,* 97-99 (1934). Carboloy and diamonds combined in solid shapes for superhard tools.

(3535) Impact Abrasion Hardness of Molded Boron Carbide and of Some Cemented Tungsten and Tantalum Carbides. L. H. Milligan and R. R. Ridgway, *Trans. Electrochem. Soc., 68,* 131-37 (1935). Abrasive tests on different grades of cemented tungsten and tantalum carbide alloys gave relative abrasion hardness values.

(3536) The Working Value of Abrasives in Comparison with Diamonds. W. Dawihl, K. Schröter and M. Stockmayer, *Z. Ver. deut. Ing., 80,* 1001-1003 (1936). In the abrasion test by sandblasting with fused alumina to determine the hardness, metals due to their greater toughness take a higher position on the hardness scale than in the Rockwell tests.

(3537) The Diamond and Its Uses in Industry. E. L. C. Tappin, *Junior Inst. Eng., London, 46,* No. 12, 533-45 (1936). Diamond impregnated slitting wheels for cutting sintered carbides are described.

(3538) Diamond Tools. *L'Expansion Belge et Exportation Réunis, 30,* No. 2, 121-28 (1937). Diamond-impregnated lapping wheels for shaping and polishing carbide tools are described.

(3539) Tests with Pure Boron Carbide Products. W. Dawihl and K. Schröter, *Werkstattstechnik, Werksleiter, 31,* 201-204 (1937). Sandblasting nozzles of boron carbide are found superior to those of cemented carbides.

(3540) Standardization of Diamond Grinding Wheels. A. Meyer, *Schleif- und Poliertech., 15,* 81-85 (1938). German standards are given for diamond-impregnated, metal-bonded wheels for coarse and fine grinding cuts.

(3541) Crystalline Titanium Nitride. V. P. Remin-Ufan, *Vestnik Metalloprom., 18,* 54-62 (1938). The production of crystalline TiN by melting a mixture of the powdered ingredients is described; the material may serve as an abrasive.

(3542) Diamond Tools. R. Spies, *Werkzeugmaschine, 42,* 528-38 (1938). Diamond-impregnated sintered metal compositions for grinding tools are described.

(3543) Diamond as a Polishing Agent. *Schleif- u. Poliertechnik, 16,* 114-117 (1939). A review of early industrial uses of diamond for polishing, sawing and drilling (*e.g.*, rocks), with the diamonds pressed, hammered or rolled into steel, or bonded by copper, is given.

(3544) Diamond Hard Metal for Grinding. W. Dawihl and A. Fehse, *Maschinenbau-Betrieb, 18,* No. 13, 349-350 (1939). Hard metal as matrix, size of the diamond particles, and uses of diamond hard metal tools are discussed.

(3545) Type of Diamond Drill Bit for Mining. V. L. Bosazza, *J. Chem. Met. Mining Soc. S. Africa, 41,* 192-193 (1940). Discussion to Wilson's article (No. 3550): graphitization of diamonds; formation of the glaze; production of dust.

(3546) Enlarged Fields of Application of Diamond Tools. F. Rollfinke, *Maschinenbau-Betrieb, 19,* No. 3, 109-110 (1940). Author refers to the selection of different matrices for the embedding of diamond splinters.

(3547) Progress in Artificial Refractories and Abrasives. F. J. Tone, *Metal Progress, 37,* No. 3, 268 (1940). A brief outline including powdered metals.

(3548) The Raw Material Situation for Industrial Diamonds and Diamond Tools. F. Urbanek, *Schleif- u. Poliertechnik, 17,* 2-4 (1940). Diamond impregnated truing tools and grinding wheels are described, and various metal and hard alloy binding matrix materials are discussed.

(3549) Diamond Impregnated Cemented Carbide for Core Bits. W. C. Weslow, *Mining Tech.*, T. P. 1172, Class A, Metal Mining, No.116 (1940), 12 pp.; *Mining and Met., 21,* 268 (1940). New bits may revolutionize the drilling with development of high-speed and light weight rotary equipment, to replace the percussion-type drills.

(3550) Type of Diamond Drill Bit for Mining. D. A. P. Wilson, *J. Chem. Met. Mining Soc. S. Africa, 41,* 290-292 (1940). Experimental machines and instruments; relation between the degree of loading, penetration and life; factors influencing the critical load and life.

(3551) Manufacture of Diamond-Impregnated Tools. *Machinery (London), 57,* No. 1480, 561-4 (1941). Methods employed at works of Impregnated Diamond Products Ltd.

(3552) Impregnated Drill Bits. D. A. P. Wilson, *S. African Mining Eng. J., 52,* Part I, No. 2528, 605 (1941). Review of recent developments and intensive research work. Different matrices are used. Applications.

(3553) Saving Diamonds for Drawing Dies. W. Dawihl, *Schleif u. Poliertechnik, 19,* 132-4 (1942). Hard Metals, B and Si-carbides proved to be useful substitutes for diamonds for drawing dies, though not quite so efficient.

(3554) Diamond Dies for Wire Drawing. B. P. Dudding, C. G. Eden and R. E. Leeds, *Metal Ind. (London), 61,* No. 19, 290-93 (1942). Lowest quality diamonds broken down into powder and chemically treated to remove foreign matter; resulting fine grade powder has improved drilling qualities.

(3555) P. Grodzinski, *Diamond and Gem Stone Industrial Production.* N.A.G. Press Ltd., London, 1942, 256 pp. Sintered carbides and diamond dies, diamond dust, and diamond dust impregnated tools are treated. Grinding and lapping of sintered carbides are also described.

(3556) Sprayed Metals Are Finished by Grinding. C. S. Reasby, *Grits and Grinds, 34,* No. 9, 6-12 (1943). Details of method and equipment used in grinding of metallized surfaces and correct grinding wheel specification are given.

(3557) Diamond Impregnated Tools. J. Hinnüber, *Berg- u. Hüttenmänn. Monatsh. Montan Hochschule, Leoben, 89,* No. 10, 117-124 (1944). A review is given, and the various diamond-metal composites are described.

(3558) Diamond and Sintered Carbide Wire Drawing Dies. *Ind. Diamond Rev., 5,* No. 57, 145-147 (1945). Diamond powder has needle shape particles. Hand versus machine polishing; use of diamond paste; drawing lubricants are discussed.

(3559) Producing Diamond Dies for Superfine Wires. *Ind. Diamond Rev., 5,* No. 58, 196-7 (1945). Natl. Bur. Standards undertook an investigation of small size diamond dies to improve manufacturing processes. Testing includes use of polarizing microscope.

(3560) Diamonds Impregnated in Carbide Speed Up Wheel Recess Drawing. *Iron Age, 155,* No. 7, 59 (1945). Saving in time and money by use of wheel dressers made with small commercial diamonds set into a matrix of Carboloy cemented carbide.

(3561) Diamond Dies. *Steel, 116,* No. 12, 122, 124, 127, 166 (1945). Results of work at National Bureau of Standards in developing improved methods for producing dies for superfine wire are presented.

(3562) Industrial Diamonds. P. Grodzinski, *Aircraft Production, 7,* No. 1, 3-6 (1945). Types of stones; choice of stones; diamond structure; orientation of truing diamonds, diamond powder.

(3563) Diamond Tool Patents I. For Machining Metals and Non-Metallic Substance. P. Grodzinski and W. Jacobsohn, Industrial Diamond Information Bureau, London, April 1945. A collection of the pertinent patent references is given.

(3564) Diamond Abrasive Wheels Sharpen Teeth of Industry. W. N. Pratt, *Western Metals, 3,* No. 2, 24, 27 (1945). Description of manufacturing methods, one employing synthetic resins, another powder metallurgy.

(3565) Crystalline Titanium Nitride. V. P. Remin-Ufan, *Metallurgia, 32,* 160-162 (1945). Crystalline TiN may be used as substitute for diamonds in abrasive applications.

(3566) Securing Diamonds in Wheel Dressing Tools. H. L. Strauss, Jr., *Machinery (N. Y.), 51,* No. 10, 179 (1945). Description of 4 principal methods of securing diamonds in tools: powder metallurgy; brazing; casting; induction heating.

(3567) Graded Diamond Powders Contained in Compound. *Steel, 119,* No. 23, 118 (1946). Hyprez diamond compound manufactured in a variety of grades is said to be highly suitable for finishing metals, sintered carbides, etc.

(3568) Diamond-Hard-Metal. G. M. Butler, C.I.O.S. Rept. No. XXX-8 (1946). Made by Krupp by hot-pressing a 3:1 mixture of W carbide and Ni with 10% diamond dust; used for grinding tungsten carbide parts. Metallwerk Plansee made three grades, using as binder tungsten carbide-titanium carbide-cobalt, "Heavy Alloy", and iron, respectively.

(3569) Diamonds as Cutting Tools. J. R. Roubik and J. P. Bunce, *Steel, 118,* No. 22, 111, 154 (1946). Despite tremendous strides in development of man-made materials of extreme hardness, industry would be unable to carry on without diamonds on many vital operations.

(3570) Diamond Dies for Wire Drawing. C. K. Wall, *Materials and Methods, 23,* No. 3, 717-19 (1946). Diamond dies, long a product of handcraftsmen, are now turned out in large quantities by high-speed precision methods.

(3571) Diamond Splinters for Truing. *Ind. Diamond Rev., 7,* 116 (1947). Description of how diamond chips mounted in soft brass were used in Germany during the war.

(3572) Diamond Powder Increases Polishing Efficiency. *Iron Age, 159,* No. 11 (1947). New diamond powder with closer range of particle size is crushed and graded by Elgin Watch Co.

(3573) German Abrasive Industry. *Steel, 121,* No. 22, 128 (1947). Dept. of Comm. PB-80333: Aluminum oxide and silicon carbide are standard materials used in Germany for manufacturing grinding wheels, honing stones, coated abrasives. Fabrication is judged to be beyond the state of American industry.

(3574) Purpose and Aims of Diamond Technology. P. Grodzinski, *Ind. Diamond Rev., 7,* No. 77, 97 (1947). Paper contributed to first Am. Convention of Industrial Diamond Assoc., New York, Jan. 27-29, 1947. Bibliography of industrial diamond applications. Patent survey by Research Dept. of Ind. Diamond Distributors (1946).

(3575) Diamond Boart. Studiengesellschaft Hartmetall. F. D. Rept. No. 3754/47 (1947). According to this report of 1935, in purifying recovered diamond boart, considerable amounts of quartz were discovered by sink-and-float separation with bromoform. The origin of the quartz was traced to three operators. Glycerin is cheaper and more effective than olive oil for fractionating silicon carbide. Its use is also proposed for diamond boart.

(3576) Diamond Boart. Studiengesellschaft Hartmetall. F. D. Rept. No. 3800/47 (1947). This report of 1939 shows that diamond boart could be electrolytically deposited in a nickel-plating, the bath being prepared in accordance with Pfanhauser, "Galvanotechnik," No. 2, 6th edition, 1922, p. 677. The use of such diamond-impregnated nickel disks was to be tested.

(3577) Diamond Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3809/47 (1947). In 1939, diamond hard metal tools were made successfully both by hot-pressing and by pressing and sintering. These were the first experiments to check the Carboloy patents.

(3578) Grinding Wheels. Studiengesellschaft Hartmetall. F. D. Rept. No. 3840/47 (1947). The report, dating from 1940, states that carborundum wheels are inferior to diamond wheels for sharpening carbide tips.

(3579) Diamond Tools. Studiengesellschaft Hartmetall. F. D. Rept. No. 3852/47 (1947). Diamond tools bonded with 65% W, 4% graphite, and 31% nickel (according to a German Patent application by F. H. Willey, Detroit) were found in 1940 to be practically equivalent to tungsten carbide-bonded diamond tools.

(3580) Grinding Wheels. Studiengesellschaft Hartmetall. F. D. Rept. No. 3991/47 (1947). Reprints of various articles of 1943 on the finishing of grinding wheels; the standardization of diamond powder fractions; and the effect of vibrations on the life of diamond hardness testers.

(3581) The German Industrial Diamond Industry. G. J. Trapp, R. P. Eccles, P. Grodzinski, H. E. Junes, R. E. Leeds, N. Robinson, N. R. Smith, and D. B. Vallance, B.I.O.S. Final Rept. No. 1448 (1947). Diamond tools were made by the Neven process, *i.e.*, by bonding diamond dust with Fe powder.

(3582) German Hard Metal Industry. G. J. Trapp, B. E. Berry, H. Burden and T. Raine, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, Special Report No. 38, London, 1947, 92-98; *Met. Powd. Rept., 1,* No. 11, 170-172 (1947). Report on BIOS trip Sept.-Oct. 1945 includes section on Kieffer's special die of carbide-bonded diamond tools.

(3583) Polishing Metal Specimens with Diamond Dust. G. C. Woodside and H. H. Blakett, *Metal Progress, 51,* No. 6, 945-947 (1947). Climax Molybdenum Co. has employed diamond dust paste containing hard, friable Mo carbide. Inclusions in steel were retained.

(3584) New Material for Drill Bits. *Eng. Mining J., 149,* No. 3, 73 (1948). A short write-up for Carbometals Ltd., London, who make diamond drill bits bonded with products from a fused mixture of boron carbide, silicon carbide, and alumina. Material can be used for cutting tungsten carbide.

(3585) New Diamond Wheel Recommendations for Carbide Grinding. F. J. Benn, *Grits and Grinds, 39,* No. 8, 1-5 (1948). Information on wheel specifications is tabulated.

(3586) Diamond Tool Patents II. Diamond Abrasive Wheels. P. Grodzinski, Industrial Diamond Information Bureau, London, Aug. 1948. Patent references.

(3587) Resin-Bonded Diamond Wheels. P. Grodzinski, *Plastics, 12,* No. 9, 453-54 (1948). Some patents are discussed.

(3588) Method of Reclaiming Industrial Diamonds from Drill Bits. A. R. Hazelgrove, *Can. Metals, 11,* No. 9, 26 (1948). A mixture of equal parts of 70% nitric acid, 60% hydrofluoric acid, and 85% phosphoric acid dissolves salts remaining from the usual acid treatment.

(3589) Recovery of Diamonds from Used Drill Crowns. A. Leibowitz and R. S. Young, *J. Chem. Soc. S. Africa, 48,* 391-400 (1948). Describes an experimental plant for the electrolytic removal of the matrix.

(3590) Developments in the Field of Industrial Diamonds. F. M. MacFall, *The Frontier, 11,* No. 3, 10-13 (1948). A precision diamond band sawing machine which permits contour sawing of hard metals and vitreous materials. The saw consists of cylindrical segments composed of diamonds bonded in a sintered tungsten alloy matrix.

(3591) Wheel Dressing Tools. *Steel, 124,* No. 11, 90, 131 (1949). Improved method for setting diamonds in various sizes of wheel dressing tools in use at Ford Motor Co. is described; powdered A-metal employed for bonding, this material being a mixture of cadmium, copper, chromium and nickel powders, together with special fluxing agent.

(3592) Increased Use of Hard Carbides for Wear Resistance. J. S. Gillespie, *Metal Progress, 56,* 523-26 (1949). An illustrated article showing diamond impregnated grinding wheel dressers.

(3593) Electro-Deposition in Production of Diamond Tools. P. Grodzinski, *Electroplating and Metal Finishing, 2,* No. 2, 78-82 (1949). Review of patents on electrolytic bonding of diamond grains with special reference to producing thin walled sawing, grinding, boring, and trepanning bodies.

(3594) Amalgams and Sintered Metals with Diamonds and Metal Oxides. W. Hennig, *Einführung in die Pulvermetallurgie.* Technische Hochschule, Graz, pp. 185-96 (1949). Sintered grinding tools impregnated with diamonds are described. Discussion also includes metal-metal oxide materials.

(3595) Characteristics of Metallographic Polishing Powders. E. C. Rollason, E. Sharratt and R. R. Roberts, *J. Iron Steel Inst., 162,* Pt. 3, 265-70 (1949). Attempt made to determine physical characteristics necessary in abrasive powder, with special reference to alumina and its methods of preparation; polishing depends largely on frictional characteristics between flat plates of polishing powder and specimen; table gives physical data and polishing properties of various samples of alumina and other metallic oxides.

3. ELECTRICAL MATERIALS AND PRODUCTS

(3596) Powder Metallurgy in the Electrical Field. C. Hardy, *Metal Progress, 36,* No. 1, 57-59 (1939). The manufacture of commutator segments and rotor cages from copper powder are described.

(3597) Electrical and Electronic Components from Powdered Metals. E. I. Shobert, II, *Proc. Third Ann. Spring Meeting Metal Powd. Assoc.,* New York, May 27, 1947, pp. 57-66. Consideration of role powder metals play in the properties of electrical components. Electrical contacts and metal graphite brushes are discussed.

A. Contacts and electrodes (refractory metals, compounds, composites and alloys)

(3598) Boron: Its Properties and Preparation. E. Weintraub, *J. Ind. Eng. Chem., Ind. Ed., 5,* 106-115 (1913). Sintered bodies from boron powder have shown a high temperature coefficient of resistivity and have therefore been used for starter contacts, etc.

(3599) Tungsten Contacts. H.v.Fleischbein, *Elektrotechn. Anzeiger, 35,* 161 (1918); *Elektrotechn. Z., 39,* 445-446 (1918). Disks of 0.5 mm. thickness, punched out of sheet tungsten, are spot-welded onto iron pins for automotive ignition points.

(3600) Tungsten Contacts. P. Schwarzkopf, *Helios Fach-Z. Elektrotechnik, 27,* 522-23 (1921). A review is given of the various applications for tungsten contacts, especially in the automotive field for distribution points.

(3601) Copper-Tungsten Electrodes. *Machinery (N. Y.), 32,* 667 (1926). An alloy of Cu and W which does not anneal at red heat is used for tipping electrodes of spot welding machines.

(3602) Temperature of a Contact and Related Current-Interruption Problems. J. Slepian, *J. Am. Inst. Elec. Engrs., 45,* 930-33 (1926). An approximate formula is given for the increase in temperature of contacts.

(3603) Non-Ferrous Metals and Alloys. *J. Soc. Automotive Eng., 25,* 305-06 (1929). "Elkonite" is a mixture of W and Cu used for welding electrodes.

(3604) Material Transfer in Electric Circuit Breakers. R. Holm, F. Guldenpfennig and R. Stoermer, *Wiss. Veröffentl. Siemens-Konzern, 14,* 30-55 (1935). It is shown that the unit loss in weight per coulomb depends upon the atomic volume of the metal, the characteristic arc voltage, and the hardness of the contact material.

(3605) Developments in the Electrical Industry During 1934. J. Liston, *Gen. Elec. Rev., 38,* 5-62 (1935). Review contains a paragraph on new and superior contact material made from powders.

(3606) Contacts with Metal Tips for Oil Switch. K. Meier, *Elektrotech. Z., 57,* No. 18, 493-95 (1936). Materials for contacts containing 60% W and 40% Cu have 6 to 8 times the life of plain copper contacts.

(3607) Electrical Contact Point Material. G. Suzuki, *Japan Nickel Rev., 4,* No. 1, 63-74 (1936). "Metallic" carbon, consisting of Ag powder mixed with C, is used. Pt-Ir contact points are ideal. Tables of properties of precious metal alloys are given.

(3608) Tablet-Making Machine. *Ind. Equipment News, 5,* 50 (1937). Tungsten powders are compressed automatically into electrical contact points.

(3609) Sintered Silver Alloys for Electrical Contacts. *Metal Ind. (London), 51,* No. 18, 461 (1937). Contacts are made by Allgemeine Elektrizitäts Gesellschaft by sintering a mixture of Ag and Pb with 2% Mo.

(3610) W. Burstyn, *Elektrische Kontakte.* Springer, Berlin, 1937, 79 pp. The text deals largely with theoretical considerations. Tungsten and composite refractory-metal-base contact metals are referred to.

(3611) Compound Metals for Electrical Contacts. G. Windred, *Elec. Engr. (London), 4,* 1045-46 (1937). Electrical contacts based on refractory metals from metal powders are described, and a review is given of the many types of switch gears, circuit breakers, and heavy duty contacts (based on a mixture of refractory metal and conductor metal) that perform satisfactorily.

(3612) Wear of Electrical Contact Points. W. Betteridge and J. A. Laird, *J. Inst. Elec. Engrs. (London), 82,* 625-32 (1938). The conditions of voltages and current necessary for the formation of the different stages in the break of a current are described.

(3613) Alloys for Electrical Application – Development of Materials. S. V. Williams, *Metal Ind. (London), 52,* 49-51 (1938). "Heavy alloy" and other contact point materials are discussed.

(3614) Where Contacts Count. *Inco., 16,* No. 3, 10-11 (1939). Describes the production and properties of "Gibsiloy," a sintered alloy of 40% Ni and 60% Ag.

(3615) Silver and Its Alloys for the Arts and Industries. J. L. Christie, *Metals & Alloys, 10,* No. 10, 300-5 (1939). A pictorial story with photographs by Don Graf. Pictures 16-17 show cold-pressing of 70-30 Ag-Ni mixture for electrical contacts, and hot-pressing of 95-5 Ag-graphite mixture into dense bars for rolling into sheet and cutting into usable forms.

(3616) Heavy Duty Contacts. L. B. Hunt, *Elec. Rev. (London), 124,* No. 3201, 459-460 (1939). "Elkonites" consists of W, Mo or their carbides mixed with Cu or Ag. The principal use is arcing tips on circuit breaker arms.

(3617) Metal Contacts. J. J. Went, *Phil. Tech. Rev., 4,* 332-333 (1939). The electrical resistance of powder metallurgy contacts is discussed.

(3618) Electrical Contacts. *Mach. Design, 12,* 80 (1940). Electrical contacts made of nonferrous powder metal compositions known as "Gibsiloy" are described.

(3619) Contact Problems in Switchgear. L. B. Hunt, *Elec. Ind., 40,* No. 3, 82-83 (1940). Reference is made to Cu-W powder metal products for contacts of oil circuit breakers and to Ag-W contacts for medium voltage air break switchgear.

(3620) Contact Materials Made by Powder Metallurgy. R. Kieffer, *Z. tech. Physik, 21,* No. 2, 35-40 (1940). Sintered contact material combinations, especially of the refractory metal-base type. Methods for their production.

(3621) Use of Silver in Sliding Electrical Contacts. H. M. Parshall and S. B. Wiltse, *Am. Silver Producers Research Project, Suppt. IV,* 1940, 8 pp. 60% silver-graphite brushes have a longer life for steel and cast iron slip ring service.

(3622) Contact Metals. S. H. Parsonage, *Elec. Eng. (London), 10,* 828-31 (1940). Composite refractory metal base contacts are described and their increased wear and life is shown by examples.

(3623) G. Windred, *Electrical Contacts.* Macmillan & Co. Ltd., London, 1940. Chapter VII, "Contact Materials," refers also to sintered material.

(3624) Switchgear Contacts. G. Windred, *Engineer (London), 169,* No. 4406, 558-559; No. 4407, 567-568 (1940). The use of sintered materials for contacts is discussed.

(3625) Metals and Alloys for Electrical Contacts. J. C. Chaston, *Metal Treatment, 6,* No. 24, 143-144 (1941). The choice of contact material is discussed for instrument contacts, medium-duty contacts, air-break contacts, air break and oil break switchgear.

(3626) Manufacture of Electrical Contact Material. E. Dürrwachter, H.E.C. Docum. No. 12627 (1941). Silver-colloidal graphite contacts contain appreciable amounts of Au, Cu, Pd, Ni, Mn or Be.

(3627) Tungsten-Copper for Electrical Contacts. F. R. Hensel, E. I. Larsen and E. F. Swazy, *Metals & Alloys, 13,* No. 5, 577-83 (1941). Properties, characteristics, analysis, applications.

(3628) R. Holm, *Die technische Physik der elektrischen Kontakte.* Springer, Berlin, 1941. A discussion of the adherence of contacts, and sintering and welding is given on pp. 130-136.

(3629) Relay Contacts. *Elec. Rev. (London), 130,* 651-652 (1942). Relay contacts; new materials for heavy duty, powder metallurgy, such as silver-nickel alloys, Elkonite described.

(3630) Electrical Contact Problems. *Engineer, 174,* No. 4519, 146-9 (1942). Discussion of problems of arcs, critical current, conductivity, material transfer, etc.

(3631) Relay Contacts. H. R. Brooker, *Elec. Rev. (London), 130,* No. 3365, 651-652 (1942). "Elkonite" shows finely dispersed particles of Ni in Ag matrix which are responsible for the freedom from sticking and resistance to wear and arcing.

(3632) Tungsten Carbides in Electrical Contacts. F. H. Clark, *Powder Metallurgy* Am. Soc. Metals, Cleveland, 1942, Chap. 43, pp. 493-496. Current relays for telegraph systems with tungsten carbide contacts as special application.

(3633) Contact Problems. H. H. Hausner, *Bull. Schweizer Elektrotechnische Verein, 33,* No. 2, 29-35 (1942). Critical current, conductivity, microstructure, physical properties.

(3634) Compound Contact Metals. H. H. Hausner and P. W. Blackburn, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 41, pp. 470-482 (1942). Discussion of theoretical fundamentals such as critical current, conductivity, material transfer; metallurgy of contact metals; properties, microstructure, hardness strength and conductivity; life of contact metals.

(3635) Physical Properties of Metal Compositions with a Refractory Metal Base. F. R. Hensel, E. I. Larsen, and E. F. Swazy, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 42, pp. 483-492., W-Cu combinations studied for specific gravity, expansion characteristics, hardness, tensile properties, compressive strength, electrical conductivity; also discussed are recent developments, and applications for contact metals and welding electrodes; microscopic analysis is given.

(3636) The Physics of Sinter Metal Contacts. R. Holm, *Kolloid-Z., 104,* No. 2/3, 231-33 (1943). High-current switches operating under oil or water are suitably made from sintered W or Mo saturated with molten Cu or Ag. For low-current switches sintered W is more suitable.

(3637) Electrical Contacts. C. B. Gwyn, Jr., *Metals & Alloys, 21,* No. 5, 1318-1323 (1945). A review of 40 elements shows that W, Ag, Pt, Mo, C-impregnated materials, and Cu alloys, in order named, offer best service.

(3638) Pressed-Powder Electrical Contacts Using Graded Multiple-Layers. H. H. Hausner, *Product Eng., 16,* No. 9, 618-20 (1945). Difficulties in construction of contacts can be overcome by forming the contact points in multiple layers, thus grading the electrical and mechanical properties.

(3639) Electrical Contacts Manufactured from Metal Powders. E. I. Larsen, *Trans. Am. Inst. Mining Met. Engrs., 161,* 554-7 (1945). Classes of contacts, varieties, manufacture, considerations in adopting powder metallurgy.

(3640) New Series of Contacts Made by Gibson. *Electrical World, 125,* No. 11, 140 (1946). New electrical contacts made from metal powders comprise a range of combinations in the Ag-W series from 10-80% W and in the Ag-W-carbide series from 20-80% W-carbide with hardness from 80-100 Rockwell B.

(3641) Sintered Metallic Powders for Electrical Contacts. *Engineering, 161,* No. 4180, 188-190 (1946). The exacting requirements which circuit breakers are expected to meet are likely to be facilitated by the development of sintered metallic powders for the manufacture of the switch contacts.

(3642) New Alloy Electrical Contacts. *Materials & Methods, 23,* No. 2, 570 (1946). A new series of electrical contacts made from silver tungsten and silver tungsten carbide is reported produced by Gibson Electric Co., Pittsburgh, Pa.

(3643) R. Holm, *Electric Contacts.* Almquist and Wiksells, Upsala, 1946. A fundamental text in English, which emphasizes the theoretical aspects of the subject. Material transfer, wear, oxidation, contact resistance, etc. are discussed.

(3644) L. B. Hunt, *Electrical Contacts.* Johnson, Matthey, London, 1946. The practical aspects of the subject are presented as a text. Reference is made to contacts from refractory metals.

(3645) Making Electrical Contacts with Metal Powders. E. I. Larsen, *Steel, 118,* No. 4, 119, 161-2, 165 (1946). Classified according to method of fabrication and components that make up chemical composition: Class I composed of silver or copper and a refractory metal powder, class II composed of silver and a semi-refractory material. Light and heavy duty contact applications are described giving composition of materials used; factors influencing use of powder metallurgy products discussed.

(3646) Cadmium Oxides – Silver Materials for Difficult Contact Jobs. E. F. Swazy and V. E. Heil, *Elec. Mfg., 38,* No. 3, 106, 186 (1946). New material, not an alloy, but a mechanical mixture, shows excellent performance when making and breaking heavy currents with low contact resistance and low temperature rise.

(3647) Contact Materials with Silver Base. K. W. Froehlich, *Metallforschung, 2,* No. 1/2, 29-30 (1947). Ag-W alloys prepared by powder metallurgy process have favorable contact properties, also contacts produced of Ag with 20-30% Ni or Fe.

(3648) Electrical Contacts. F. R. Hensel, F.I.A.T. Rept. No. 785, 1947, 27 pp.; *Met. Powd. Rept., 1,* No. 7, 105 (1947). References to powder metallurgy include production of special tungsten powders and contacts made therefrom.

(3649) Some Aspects of Electrical Contact Materials. N. E. Hyde, R. A. Woodford, K. W. Lee-Kemp, J. S. Young and A. C. Lynch, B.I.O.S. No. 1276 (1947).

Phenomena associated with design of electromechanical devices used in German telecommunication equipment.

(3650) Making Electrical Contacts with Metal Powder. E. I. Larsen, *Steel, 118,* No. 4, 119, 161, 162, 165 (1947). A discussion of the use of powder metallurgy for the fabrication of contacts, including density, physical properties, thermal conductivity, resistance to corrosion.

(3651) Precious Metals as Materials for Electrical Contacts. G. Siebert, U.S. Dept. Comm. PB. 25782/1944, 375 pp.; *Bibl. Scient. & Ind. Rept., 5,* No. 10,888 (1947). This F.I.A.T. microfilm reel consists of 11 items of precious metals and their alloys as contact material, including powder metallurgy products.

(3652) Preparation and Examination of Contact Material. Staatliches Forschungsinstitut fur Metallchemie. F. D. Rept. No. 1594/46, 1946, 18 pp.; *Met. Powd. Rept., 1,* No. 5, 76-77 (1947). Contains experimental study of the systems W-O, W-Ni-O, W-Ag-O; W-Ni with 10% Ni is claimed to be excellent contact material.

(3653) Tungsten Contacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3856/47 (1947). Tungsten contacts were pointed by electrolytic etching in 20% NaOH at 120 V. This process was developed by 1940 for the Telefunken Co. who used it on a large scale. Steel needles could also be electrolytically etched in dilute phosphoric acid at up to 30 V.

(3654) Tungsten-Free Hard Metals. Studiengesellschaft Hartmetall. F. D. Rept. No. 3947/47 (1947). According to this report of 1943, W-free hard metals are not suitable for the manufacture of electrical contacts.

(3655) Electrical Contacts. F. R. Hensel, U.S. Dept. Comm. PB. 32586, 1948, 25 pp.; F.I.A.T. Final Rept., No. 785 (1948). Composition, properties, production of contact alloys and the German factories are discussed. Methods used for bonding inlays and overlays to inexpensive basic material. Application of contacts.

(3656) The Deformation of Metals in Static and Sliding Contact. A. J. W. Moore, *Proc. Roy. Soc. London, A195,* 231-44 (1948). An examination of the surface damage produced during the sliding shows that metallic junctions are formed and sheared.

(3657) Sintered Contact Materials. R. Palme, *Einführung in die Pulvermetallurgie,* Technische Hochschule Graz, 1949, pp. 172-84 (1949). Physical properties, conductivity, contact resistance, structures.

(3658) Sintered Contact Materials. R. Palme, *Oesterr. Maschinenmarkt u. Elektrowirt., 4,* 240-42 (1949). Discussion of material for contacts produced by the sintering of powder mixtures.

B. Current collector brushes

(3659) Carbon Brushes for Motors and Generators. G. M. Little, *Iron and Steel Eng., 6,* 110-13 (1929). A review is given of the subject of current collector brushes.

(3660) H. Stephan, *Die heutige Bedeutung der Stromabnehmerbürste.* Ringdorffwerke KG, Mehlem/Rhein, 1942. On p. 19 the physical properties of several metal-carbon brushes are tabulated.

(3661) High Altitude Brush Problems. D. Ramadaroff and S. W. Glass, *J. Am. Inst. Elec. Engrs., 63,* 825-29 (1944). The problems connected with high altitude service of commutator type electrical machinery and the effect on the brushes are discussed and a new type of high altitude copper-graphite brush is described.

(3662) Brushes and Allied Powder Metal Parts. R. R. Hoffman, *Trans. Am. Inst. Mining Met. Engrs., 161,* 550-558 (1945). Special advantages of metal-graphite brushes; design of brushes and parts; tolerances; physical properties of metal-graphite material; manufacturing advantages.

(3663) Carbon Brush Industry. H. H. Wikle and W. A. Steiner, F.I.A.T. Rept. 115 (1945). An account of high-altitude brushes; industrial brushes; metal-graphite brushes.

(3664) Carbon Brush Industry of Germany for Electrical Equipment. W. Littlejohn, D. B. Foster, and K. G. Budden, B.I.O.S. Final Rept. Nos. 1181, 1230 (1947). Electrolytic Cu powder and Bavarian graphite were used in ratios of 5:1 or 20:7 for different applications.

C. Heating elements, resistor, and semi-conductor materials

(3665) Silicon Carbide. F. Bölling, *Elektrotech. Z., 30,* 165, 789-790 (1909). Pressed powdered carbon tubes or rods are treated in silicon vapor at high temperatures and result in resistor elements.

(3666) Silicon Carbide. K. Perlewitz, *Elektrotech. Z., 34,* 263-267 (1913). The electrical properties, temperature stability, heat conductivity, permeability to gases etc. are discussed, and applications such as resistor elements and protection tubes for thermocouples are cited.

(3667) Silicon Carbide. E. Egly, *Helios Export-Z. Elektrotechnik, 20,* 257-261, 381-386 (1914). A mixture of the elemental silicon and carbon plus an organic binder which readily volatilizes are pressed into shape and heated or hot pressed, until the silicon liquefies. The resulting bodies are suitable as electrical heating elements, resistors, etc.

(3668) Electrical Conductivity of Zinc Oxide. F. Skaupy, *Z. Physik, 1,* 259-260 (1920). Sintered oxide-base bodies with negative temperature coefficient of resistance are described as semi-conductors.

(3669) P. Reinglass, *Chemische Technologie der Legierungen,* Spamer, Leipzig, 2nd Ed., 1926. The electrical properties and, in particular, the temperature coefficient of resistance of metal-nonmetal combination bodies for resistor elements, such as produced by stirring ceramic particles into molten metal, are discussed on pp. 90-91.

(3670) Chrome-Nickel Alloys and Their Life Testing. W. Hessenbruch and W. Rohn, *Elektrowärme, 3,* 245-49; 317-22 (1933). Different heat resistant alloys (*e.g.,* nickel-chromium and iron-aluminum alloys) are discussed, and their respective temperature ranges as resistor heating elements are reviewed.

(3671) A New Heat Resisting Alloy. S. L. Hoyt, and M. C. Scheil, *Trans. Am. Soc. Metals, 23,* 1022-46 (1935). It is shown that Ni-Cr alloys are suitable as resistor material up to 1150° C. (2100° F.).

(3672) Report on Tests of Various Electric Heating Elements. M. G. Toole, and R. E. Gould, *Trans. Electrochem. Soc., 70,* 89-109 (1936). Resistor alloy materials suitable up to about 1250° C. (2300° F.) include the nickel-free chromium bearing "Smith Alloy No. 10" or "Kanthal."

(3673) The Use of the Refractory Metals Molybdenum and Tungsten in the Electric Furnace at High Temperatures. J. Michel, *Chimie & industrie, 40,* 1060 (1938). The use of Mo and W as heating elements in the form of both wire and tubes is discussed.

(3674) Silicon Carbide. F. J. Mann, *Ver. deut. Elektrotech., Fachberichte, 11,* 101-107 (1939). Electrical properties and applications are discussed. Among important properties are heat conductivity, electrical resistivity change with time as affected by oxidation, permeability to gases. Resistor elements, thermocouple protection tubes, etc. are given as applications.

(3675) Electrical Resistance Furnaces for High Temperatures. P. Schwarzkopf, *Metals & Alloys, 13,* No. 1, 45-49 (1941). Four types of heating elements discussed, mainly "Stratit" which is trade mark for a molybdenum rod or wire spiral which is encased and sealed gas-tight by sillimanite tubing and copper terminals.

(3676) Semiconducting Ceramic Materials. H. H. Hausner, *J. Am. Ceramic Soc., 30,* 290-96 (1947). Semi-conductors or resistors with either positive or negative temperature coefficient are described as being produced from powder mixtures of refractory oxides and nickel or copper.

(3677) A Vacuum Heating Element. G. S. Lewin, *Proc. Inst. Radio Engrs., 35,* 494 (1947). A resistor element consisting of a molybdenum rod or spiral encased in a sillimanite tube is described.

(3678) Powder Products Made of Metals Plus Non-Conductors, Especially Oxides. F. Skaupy, *Die Technik, 2,* No. 4, 157-158 (1947). Review of known mixed powder metallurgy products. Group 1: Metal-base products with additions of non-conductors, *e.g.*, cemented carbides. Group 2: Non-conductor-base products with additions of metals, *e.g.*, products of special electrical properties.

(3679) Resistors. H. H. Hausner, *Bull. Am. Phys. Soc., 24,* No. 1, 40-44 (1949). Resistor or semi-conductor materials are described as being based on powder mixtures of refractory oxides and certain metal powders.

D. Electronics products

(3680) Copper Base Powder Metallurgy. H. Chase, *Materials & Methods, 24,* No. 6, 1439-44 (1946). Electronic tubes made of pure copper or sintered bronze powder are discussed.

(3681) Some Materials and Methods for X-Ray and Power Tube Manufacture. C. F. Lindsay, *Materials & Methods, 23,* No. 2, 407-411 (1946). Glass, Cu and W; sealing-in alloys; Be and Ta. Methods and testing.

(3682) New Getter Materials for High Vacuum Technique. W. Espe, *Powd. Met. Bull., 3,* No. 5, 100-11 (1948). Coating getters are applied to electrodes of vacuum tubes, which are coated with gas-binding substances, such as Ta, Zr, Th, "Ceto" getters.

E. Porous electrodes

(3683) Aircraft Batteries. L. E. Lighton, B.I.O.S. Final Rept. Misc. No. 46 (1945). A remarkably complete account of the work done by the A.F.A. Company on nickel aircraft batteries, including production figures, manufacturing data, sizes and data relating to the failure of the plates which eventually led to the abandonment of this project.

(3684) German Secondary Battery Industry. D. H. Collins, and H. B. Lunn, B.I.O.S. Final Rept. No. 467 (1946). A report on accumulator plates.

(3685) The German Accumulator Industry. D. H. Collins, and H. B. Lunn, B.I.O.S. Final Rept. No. 708 (1946). Akkumulatoren Fabrik A.G., Hagen, produced porous, lightweight sintered Ni plates for secondary batteries. Pieces of iron gauze were edged with steel tape and thinly nickel plated, by pressing them in nickel carbonyl powder or cupro-nickel powder and sintering at 900° C. (1760° F.). The plates were then vacuum-impregnated in a nickel or cadmium solution and electrolytically treated to produce nickel oxide or cadmium sponge.

(3686) The German Battery Industry. G. B. Ellis, U.S. Dept. Comm. PB. 13806/1944, 135 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 16, 848 (1946). Production of Durac batteries; instruction for sintering furnaces; impregnation of the porous sintered plates.

(3687) Aircraft Batteries. L. E. Lighton, U.S. Dept. Comm. PB. 22928/1945, 65 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 1, 24 (1946). Describes the development of a sintered porous plate construction for Ni-Cd batteries.

(3688) Miscellaneous Electrical Factories in the British and American Zones. C. G. Lloyd, and N. L. Kusters, B.I.O.S. Final Rept. No. 411 (1946). The manufacture and behavior of alkaline nickel cadmium batteries are outlined.

(3689) The German Accumulator Industry. H. B. Lunn, B.I.O.S. Final Rept. No. 708 (1946). The preparation of porous battery plates at Akkumulatoren Fabrik A. G. is described.

(3690) Nickel Cadmium Storage Batteries in Germany. P. E. Plehn, U. S. Dept. Comm. PB 42771/1946 (1946). *Cf.* F.I.A.T. Rept. No. 800, 1947.

(3691) The German Accumulator Industry. M. Barak, and B. L. Davies, B.I.O.S. Final Rept. No. 1129 (1947). Akkumulatoren Fabrik A. G., Hagen, impregnated the positive plates with nickel nitrate solution and the negative plates with cadmium chloride, both under vacuum; then the plates were electrolytically reduced to nickel oxide and cadmium sponge.

(3692) Sintered Plates for Batteries. G. B. Ellis, *Materials & Methods, 26,* No. 1, 127 (1947). Abstract of U.S. Dept. Comm. PB-53491. General survey of German battery industry. Porous plates were developed for nickel-cadmium alkaline batteries; positive base plate contained pure carbonyl Ni; negative plate contained a mixture of 30% carbonyl Ni and 70% Cu.

(3693) Nickel Cadmium Storage Batteries in Germany. P. E. Plehn, F.I.A.T. Rept. No. 800 (1947). The manufacture of nickel-cadmium storage batteries is described in thorough detail.

(3694) Anodes from Rolled, Forged and Sintered Nickel Alloys. E. R. Thews, *Metal Ind. (London), 71,* 388-389 (1947). A review on the varying types of electrolytic anodes; the operating factors involved in the fabrication of sand cast, rolled, forged, and sintered porous Ni-anodes, and their uses.

(3695) Sintered Plates for Nickel-Cadmium Batteries. A. Fleischer, *Trans. Electrochem. Soc., 94,* No. 6, 289-99 (1948). Porous plaques are prepared by sintering carbonyl nickel powder of low density; the plates are impregnated with Ni or Cd salt solutions and heavy metal ions precipitated in the pores by cathodic polarization in alkali hydroxide solution.

(3696) Sintered Plates for Nickel Cadmium Batteries. A. Fleischer, *Powd. Met. Bull., 3,* No. 5, 118 (1948). Carbonyl nickel powder of angular particle shape has proved satisfactory. The powder was packed in graphite forms around a fine nickel wire net, which imparted the mechanical strength to the sintered plates.

(3697) Powdered Iron Electrodes. L. L. Kuzmin and L. V. Borisova, *Zhur. Priklad. Khim., 21,* 378 (1948). Influence of the degree of dispersion and the composition of Fe powders on the properties of porous electrodes.

(3698) Hardness of Nickel Compacts. S. R. Williams, *Metal Progress, 56,* No. 6, 811-13 (1949). Investigation of hardness of sintered nickel plates, used as one of elements in batteries, varying in sintering time from 3 to 60 min.

4. MAGNETIC MATERIALS AND PRODUCTS

(3699) The Ferromagnetic Alloys and Their Industrial Use. W. S. Messkin, and A. Kussmann, *Die Ferromagnetischen Legierungen und ihre gewerbliche Verwendung.* Springer, Berlin, 1932, 418 pp. A section on magnetic cores and permanent magnets is found on pages 378-386; pp. 23-60 and 218-292 discuss production, aging, and testing of permanent magnets.

(3700) Present Status of Ferromagnetic Theory. R. M. Bozorth, *Elec. Engr., 54,* 1251-61 (1935). The salient points brought out in the foregoing years are summarized.

(3701) F. Bitter, *Introduction to Ferro-Magnetism.* McGraw-Hill, London, 1937, 314 pp. Magnetic materials and their preparation are discussed in Chapter 4.

(3702) R. Becker and W. Doring, *Ferromagnetismus.* Springer, Berlin, 1939. A treatment of fundamentals, including magnetic properties and characteristics.

(3703) Japanese Magnetic Materials. *Iron Age, 160,* No. 26, 84 (1947). Four magnetic materials, not made in U. S. are being produced in Japan. Materials are an Al-Fe alloy; Sendust alloy of Fe, Si, Al; and two permanent magnet materials developed before the war. Use of Alfer alloy in magnetostriction protectors and microphones.

(3704) Magnetism. R. M. Bozorth, *Rev. Modern Phys., 19,* 29-86 (1947). The newest progress in the field of magnetic materials is discussed in detail. The discussion includes powder metallurgy products.

(3705) Sintered Iron and Steel for Structural Parts. R. Kieffer, F. Benesovsky, and H. Bartels, *Industrie u. Technik, 2,* 64-66, 88-92 (1947); *Powd. Met. Bull., 2,* No. 3, 54-69 (1947). Sintered permanent magnets and composite hard and soft magnetic structures are described.

(3706) Electronic Components from Powdered Metals. E. I. Shobert, II, *Materials & Methods, 26,* No. 2, 121-122 (1947). Abstract from paper given at Third Ann. Spring Meeting of Metal Powder Assn., New York, May 27, 1947.

(3707) Electrical and Electronic Components from Powdered Metals. E. I. Shobert, II, *Proc. Third Ann. Spring Meeting, Metal Powder Assoc.,* New York, May 27, 1947, pp. 57-66. Permanent magnets, soft magnets, high frequency cores are discussed.

(3708) Review of Magnetic Materials for Communication Systems. R. A. Chegwidden, *Metal Progress, 54,* 705-14 (1948). An account of both high-permeability materials and permanent magnet alloys, with numerous diagrams and a table of typical data. Powder metallurgy developments are mentioned.

(3709) New Ferromagnetic Materials. K. Sixtus, *Arch. Elektrotechnik, 39,* No. 12, 260-6 (1948). Characteristics of Vicalloy and Supermalloy in comparison with older types; carbonyl powders, ferrites and Ferroxcube.

(3710) Magnetic Materials and Sintered Materials with Particular Properties. H. J. Bartels, *Einfuhrung in die Pulvermetallurgie.* Technische Hochschule Graz, 1949, pp. 144-71. Cores. Magnetic properties of electrolytic iron powder. Comparison of magnetic properties of fused and sintered soft magnetic alloys. Sintered versus cast magnets. Structure of sintered Fe-Ni-Mo alloy.

A. Permanent magnets (iron-base, copper-base, oxide and molded magnets)

(3711) New Magnet Steels in Japan. *Iron Age, 130,* No. 9, 346 (1932). A permanent magnet material of the type containing 5-14% Al, 12-33% Ni, and 0-30% Co, balance Fe, and known as the Mishima type, is described.

(3712) Precipitation Hardening of Iron-Cobalt-Tungsten and Iron-Cobalt-Molybdenum. W. Köster, *Arch. Eisenhüttenwesen, 6,* 17-23 (1932). The properties of iron-cobalt-tungsten and iron-cobalt-molybdenum type permanent magnets are discussed. Alloys containing chromium in addition to the other elements are also reviewed.

(3713) Quality Index for Permanent Magnets. H. Neumann, *Arch. tech. Messen, 5,* 956 (1932). The important magnetic properties of permanent magnet materials are reviewed, and various types of material are compared.

(3714) Magnetic and Mechanical Hardness of Dispersion Hardened Alloys. K. S. Seljesaeter and B.A. Rogers, *Trans. Am. Soc. Steel Treating, 19,* 553-76 (1932). An investigation is conducted of the magnetic characteristics of Fe-W-Co alloys.

(3715) A New Magnet Material. *Stahl u. Eisen, 53,* 79 (1933). The iron-nickel-aluminum type of permanent magnet developed by T. Mishima is described.

(3716) Permanent Magnets from Powdered Iron Oxides. Y. Kato and I. Tokai, *J. Inst. Elec. Engrs. Japan, 53,* 408-12 (1933). Compacted powder mixtures of Fe_2O_3 and Fe_3O_4 are sintered at 1000° C. (1830° F.) and then magnetized at 300° C. (570° F.).

(3717) **Material for Permanent Magnets.** W. Köster, *Stahl u. Eisen, 53,* 849-56 (1933). The magnetic properties of cobalt-tungsten and cobalt-molybdenum steel permanent magnets are discussed.

(3718) **Ni-Al-Steel for Permanent Magnets.** T. Mishima, *Stahl u. Eisen, 53,* No. 3, 79 (1933). A table shows the remanence and coercive force of different magnet steels. Steel M.K.1 contains 25% Ni, 10% Al, balance Fe.

(3719) **Permanent Magnets from Oxide Powders.** K. Honda, *Metallwirtschaft, 13,* 425-27 (1934). The type developed by Y. Kato consists of iron oxide, Fe_3O_4, and cobalt ferrite ($CoFe_2O_4$) has a coercive force of 400-600 and a residual induction of 5000-3000.

(3720) **A New Permanent Magnet.** K. Honda, H. Masumoto, and Y. Shirakawa, *Science Rep. Tohoku University, Ser. 1, 23,* No. 3, 365-72 (1934). The properties of the Honda-type, cobalt alloy steel magnets are described.

(3721) **About the Knowledge of Iron-Nickel Alloys.** O. Dahl, J. Pfaffenberger, and N. Schwartz, *Metallwirtschaft, 14,* 665-670 (1935). The properties of iron-nickel-copper permanent magnet alloys are described.

(3722) **New Materials for Permanent Magnets.** A. Kussmann, *Z. Ver. deut. Ing., 79,* 1171-73 (1935). A review is given of pressed and sintered magnets from powders and their production and properties are discussed.

(3723) **Alloys for Permanent Magnets.** D. A. Oliver, *Rept. Progress Physics, 3,* 224-7 (1936). Powdered alloy magnets of mixture of iron oxide and ferro-cobalt, are mixed with binder and compressed in dies.

(3724) **Production of Magnetic Materials by Means of Powder Metallurgy.** A. Lavler, *Novosti Tekhniki* (in Russian), *6,* No. 30, 24-26 (1937); also *Chem. Zentr., 110,* Pt. 1, 1020 (1937). Permanent magnets by sintering of ferromagnetic oxides of Fe, Co, Ni.

(3725) **Soft Alloys for Permanent Magnets.** H. Neumann, A. Büchner, and H. Reinboth, *Z. Metallkunde, 29,* 173-185 (1937). A discussion of the magnetic properties of iron-nickel-copper permanent magnet alloys is presented.

(3726) **Alloys for Permanent Magnets.** W. Dannöhl, and H. Neumann, *Z. Metallkunde, 30,* 217-31 (1938). The magnetic properties of cobalt-nickel-copper permanent magnet alloys are discussed.

(3727) **Cooling of Permanent Magnet Alloys in the Magnetic Field.** D. A. Oliver, and J. W. Shedden, *Nature, 142,* 209-14 (1938); *Chem. Zentr., 109,* Pt. II, 3517-18 (1938). The magnetic quality of permanent magnets is improved by generating directional properties during heat treating.

(3728) **Recent Development in Magnetic Materials.** C. E. Webb, *J. Inst. Elec. Engrs. (London), 82,* 303-10 (1938). A broad review includes a discussion of sintered iron-nickel-aluminum permanent magnets.

(3729) **Iron Powder Compacts.** L. Wyman, *Metal Progress, 35,* No. 6, 585 (1939). Critical Points Discussed by Editor. Electrolytic iron powder of high purity is used for Alnico magnets.

(3730) **Sintering Alnico Magnets.** G. H. Howe, *Iron Age, 145,* No. 2, 27-31 (1940). Descriptive account of processing and resulting products.

(3731) **Sintered Iron-Nickel-Aluminum Magnets.** G. Ritzau, *Wissenschaftl. Veröffentl. Siemens-Werken,* Berlin, Werkstoff Sonderheft, 1940, pp. 37-44. Difficulties in melting and casting; study of pre-sintering Fe-Ni-Al powder compacts to finished dimensions and of eliminating brittleness in final product by keeping crystal size very small; difficulties to be overcome in making pore-free magnets; author's experiments and results.

(3732) **Characteristics of Materials for Permanent Magnets According to Their Properties.** W. Zumbusch, *Arch. Eisenhüttenwesen, 14,* No. 3, 127-131 (1940). A table containing the properties of different materials is given.

(3733) **Permanent Magnets.** *Elektrotech. Z., 62,* No. 27, 601 (1941). Production and properties of pressed permanent magnets are described.

(3734) **Production and Properties of Pressed Permanent Magnets.** H. Dehler, *Elektrotech. Z., 62,* No. 27, 601-606 (1941). Discussion includes powdered magnetic material and resin binder.

(3735) Production of Magnets from Sintered Fe-Ni-Al Alloys. W. Hotop, *Stahl u. Eisen, 61,* 1105-09 (1941); *Nickel Bull., 15,* 34 (1942). For making magnets, a powder is prepared containing 48-53% Al (rest Fe) which forms up to 30% of the mixture to be sintered, the rest consisting of Fe and Ni to give a final composition of Fe 60%, Ni 27%, Al 13%. Tests of effect of different pressures applied shows no change in magnetic properties. Electrically heated furnace with Mo elements and atmosphere of hydrogen used. Sintering carried out at 1200-1330°C, (2190-2420° F.) for 1 3/4 hours.

(3736) Some Experiments in the Production of Aluminum-Nickel-Iron Alloys by Powder Metallurgy. P. R. Kalischer, *Trans. Am. Inst. Mining Met. Engrs., 145,* 369-377 (1941). Effect of processing variables, moisture, shrinkage discussed. Titanium hydride used as reducing agent results in superior magnets.

(3737) Permanent Magnet Material. H. J. Merchant, *J. Birmingham Met. Soc., 21,* 210-211 (1941). Characteristics of Si-Fe and Ni-Fe alloys and permanent magnet materials including sintered alloys are surveyed.

(3738) Compacted Magnets with Resin Binder. H. Dehler, *Stahl u. Eisen, 62,* No. 47, 983-86 (1942). Permanent magnets made from metal powders containing 9-13.5% Al, 0-19% Co, or 4% Cu, 18-28% Ni, or 4% Ti and rest Fe and synthetic resin binder. The magnetic properties are 20% of the value of cast magnets.

(3739) Permanent Magnets. J. H. Goss, *Metals & Alloys, 15,* No. 4, 576-82 (1942). Their production by casting and sintering is described.

(3740) Development of Sintered Alnico. G. H. Howe, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 48, pp. 530-36. Details are given of the pressing and sintering; description of equipment.

(3741) Some Experiments in the Production of Aluminum-Nickel-Iron Alloys by Powder Metallurgy. P. R. Kalischer, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 49, pp. 537-45. Magnet alloys were produced with improved properties due to a beneficial effect of titanium hydride addition.

(3742) Alnico - Properties and Equipment for Magnetization and Test. B. M. Smith, *Gen. Elec. Rev., 45,* 210-211 (1942). Properties of cast and sintered Alnico permanent magnets. Measurement of magnetic properties. The hysteresigraph is described.

(3743) Compressed Powder Magnets with Synthetic Resin Binder. H. Dehler, *J. Roy. Aeronaut. Soc., 47,* No. 387, 86 (1943). Abstract from *Stahl u. Eisen, 62,* No. 47, 983-6 (1942). Permanent magnets are made from metal powders with an addition of synthetic resin binder.

(3744) Compressed Powder Magnets with Synthetic Resin Binder. H. Dehler, *Wireless Eng., 20,* No. 237, 314 (1943). Permanent magnet alloys of Fe-Ni-Al type compacted with 6% phenol. Abstract from article in *Stahl u. Eisen, 62,* No. 47, 983-6 (1942).

(3745) Permanent Magnets Produced from Powders. W. Hotop, *Stahl u. Eisen, 63,* 814 (1943). The production of sintered magnets is described.

(3746) M. Kersten, *Grundlagen einer Theorie der Ferromagnetischen Hysterese und der Koerzitivkraft.* Hirzel, Leipzig, 1943. Fundamental concepts are advanced that explain the extraordinary magnetic properties of ultrafine ferromagnetic powders.

(3747) Strength and Economy of Compacted Magnets. H. Dehler, *Electrotech. Z., 65,* No. 11/12, 93-94 (1944). Compacted permanent magnet materials with resin binder have greater economy than the cast magnet and complicated forms can be produced easily.

(3748) Permanent Magnets. R. L. Sandford, *U. S. Dept. Commerce, Circ. Bur. Standards No. C448,* August 10, 1944. A broad review of the subject includes powder metallurgy products.

(3749) Magnetic Potentiometer Study of Permanent Magnets. L. F. Bates, *Phil. Mag., 36,* 297-38 (1945). Laboratory methods for study of permanent magnet alloys. The use of magnetic potentiometer in a suitable form for the measurement of the B-H curves of modern permanent magnets of different shapes is described and details given of its use for an experimental investigation of the circuit relations of permanent magnets. Data presented include sintered Alnico.

(3750) Sintered Magnets. C. R. Fulton, *Trans. Am. Inst. Mining Met. Engrs., 161,* 557-564 (1945). Sintering process, design, size limitations, physical properties, diagrams.

(3751) Sintering of Fe-Ni-Al Magnets. Deutsche Edelstahlwerke, Krefeld. F. D. Rept. No. 1626/46 (1946). A file dated 1941, dealing with the preparation for publication of a paper on the above subject by W. Hotop.

(3752) Production of Sintered Permanent Magnets. Deutsche Edelstahlwerke, Krefeld. U. S. Dept. Comm. PB. 13706, 1946, 8 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 8, 512 (1946). Making sintered permanent magnets from a combination of metal powders or their alloys, *e.g.*, Fe-Ni-Al or Fe-Co-Ti. The material is subjected to a strong magnetic field during sintering and cooling.

(3753) Manufacture of Sintered Steel Magnets. Fried. Krup A.G., Essen. F.D. Rept. No. 3033/46 (1946). Contains graphs of (*1*) remanence and coercive force of sintered Koerzit 90 and (*2*) the change in carbon content with reducing temperature of carbonyl iron and nickel. A general account is given of the manufacture of Alnico magnets (November, 1945), and also of the "alitizing" process in which aluminum coatings are obtained on steel by packing in a 40/60 aluminum-alumina mixture and heating at 950-1050° C. for 4-20 hours.

(3754) German Naval Mining Relays and Moulded Powder Permanent Magnets. C. H. Fawcett, R. P. Common, and J. A. Murray, B.I.O.S. Final Rept. No.587, Item No. 15, 1946, 64 pp. (1946); *Met. Powd. Rept., 1,* No. 4, 60 (1946). A report on the status of the metal powder magnet industry in Germany is given.

(3755) Ductile Permanent Magnets. J. H. Goss, *Product Eng., 17,* No. 1, 44-47 (1946). A review includes magnets made by powder metallurgy.

(3756) Production and Properties of Pressed Permanent Magnets. S. Harris, *Plastics (London), 10,* No. 10, 534-41 (1946). The carbon steels were replaced by cobalt steels and then by Fe-Ni-Al alloys. Each new development represented a considerable increase in the magnetic energy of the material. References.

(3757) Modern Hard Magnetic Material. K. Hoselitz, *Metal Treatment, 13,* 213 (1946). Among other headlines also mentioned: sintered powder magnets.

(3758) Modern Hard Magnetic Materials. K. Hoselitz, *J. Sci. Instruments, 23,* 65-70 (1946). Sintered permanent magnets are included in a review of modern hard magnetic materials, and their application in the instrument industry.

(3759) Powdered Iron Cores. C. T. Martowicz, *Steel, 118,* No. 13, 146-48 (1946). Characteristics of electrical grade iron powders make them especially suited for use in high frequency magnetic applications.

(3760) Permanent Magnet Steels. W. E. Ruder, *Iron Age, 157,* No. 19, 65-69 (1946). A review of permanent magnet steels covering their metallurgy; engineering possibilities and physical qualities, methods of fabrication. Sintered Alnico compared with other types of permanent magnet materials.

(3761) Permet, a Non-Ferrous Permanent Magnet Made from Powders. R. Steinitz, *Powd. Met. Bull., 1,* No. 3, 45-47 (1946). Material containing about 30% Co, 45% Cu and 25% Ni now being manufactured by American Electro Metal Corp. under trade name of "Permet" is described and some properties are given.

(3762) Magnet Steels in Germany. *Iron Age, 160,* No. 20, 98 (1947). Powdered iron pressings including Alnico magnets made with resin binding. Translation of paper supplied by Krupp. PB. 75880.

(3763) Modern Magnetic Materials. H. E. Finke, *Materials & Methods, 25,* No.6, 72-76 (1947). Permanent magnet materials designed in many shapes by powder metallurgy or casting include Cunico, Silmanal, Alnico; their applications are discussed.

(3764) Production of Sintered Permanent Magnets. S. J. Garvin, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Report No.38, London (1947), pp. 67-72; *Met. Powd. Rept., 1,* No. 11, 166-7 (1947). Permanent magnets with preferred orientation, *e.g.*, Alcomax, Ticonal, Hycomax are made by sintering, comparing very favorably with cast magnets.

(3765) Materials for Magnetic Techniques. R. Goldschmidt, *Helv. Phys. Acta, 20,* 458-460 (1947). Properties of magnetic materials are discussed: Alnico, Hypersil, Ferroxcube, Supermalloy, Superisoperm.

(3766) Sintered Magnets in "Magnetfabrik Dortmund" and "Metallwerk Plansee." O. Guttmann, F.I.A.T. Rept. No. 1130, 1947, 20 pp.; *Met. Powd. Rept., 2,* No. 3, 36 (1947). In the latter at Reutte a binder of 10-20% camphor is used for the pressing of permanent magnets, while in the former at Krefeld the powder is granulated to 1-2 mm., which size was found to be non-adherent to the walls of the die.

(3767) Properties of Finely Divided Ferromagnetic Materials. L. Neel, *Compt. rend., 224,* 1488-1490, 1550-1553 (1947). A report is given on French war-time work on high coercivity iron powders for pressed permanent magnets.

(3768) Pressed Magnets. A. S. Saimowski, A. S. Kasarnowski, and I. I. Kifer, *Electroind. U. S. S. R., 18,* No. 18, 19-22 (1947). The production and properties of pressed permanent magnets are described.

(3769) Permanent Magnets from Fe-Ni-Al Powders. G. Wassermann, F. D. Docum. No. 1230/46, 1946, 15 pp.; *Met. Powd. Rept., 1,* No. 5, 77 (1947). Magnets were made at Metallgesellschaft A. G. in 1938 from 63% electrolytic iron powder, 23% Ni-carbonyl, 14% coarse atomized Al. After age-hardening at room temperature for days or weeks, the magnetic properties were improved by renewed magnetizing.

(3770) Alnico Magnets. H. R. Williams, B.I.O.S. Final Rept. No. 993, 1947, 27 pp.; *Met. Powd. Rept., 1,* No. 8, 119 (1947). Notes on production of cast and sintered Alnico magnets at Deutsche Edelstahlwerke and Friedrich Krupp A. G.

(3771) Problems of Production of Sintered Mishima Steel. F. D. Rept. No. 3543/48 (1948) (formerly H.E.C. 11914). A summary by Fahlenbrach of work that was done in 1944/5 on Alnico magnets for the purpose of recommending Widia as a production center.

(3772) New Sintering Method Improves Magnetic Material. *Materials & Methods, 27,* No. 6, 121 (1948). General Electric Co. has announced a method of sintering their permanent magnet material, Alnico 5, which permits the design of intricate shapes with higher external energy than heretofore possible.

(3773) Carbonyl Nickel and Iron Powders. S. E. Buckley, L. F. Denaro, F. Dickenson, S. J. Garvin, R. J. Halsey, W. Ivory, C. J. Leadbeater, C. E. Richards, A. E. Wallis, and J. Weaver, B.I.O.S. Final Rept. No. 1575, 1948, 35 pp.; *Met. Powd. Rept., 2,* No. 5, 68 (1948). Report covers interrogation of L. Schlecht of Oppau Works of I. G. Farbenindustrie A. G. Reference is made to patents covering the manufacture of permanent magnets from carbonyl iron and nickel powders.

(3774) Powder Metallurgy Applied to Permanent Magnets. A. E. Franks, *Iron Age, 161,* No. 15, 82-85 (1948). Various procedures for developing the properties including precautions to obtain optimum results are given in the article. Several new magnetic materials possess desirable characteristics that promise further broadening in the magnetic industry.

(3775) Permanent Magnet Material. J. H. Goss, *Mech. Eng., 70,* 671-74 (1948). A review includes the sintered types of Alnico.

(3776) Permanent Magnets from Powders. R. A. Hetzig, *Iron Coal Trades Rev., 157,* No. 4216, 1474 (1948). Author points out that because of their hardness and brittleness when cast, certain magnets are now manufactured from powders by sintering. Good magnetic properties depend on extreme fineness and lattice formation.

(3777) Permanent Magnets from Pure Iron Powders. R. Steinitz, *Powd. Met. Bull., 3,* No. 6, 124-27 (1948). A review is given of the underlying principles and production methods involving ultrafine powders.

(3778) Permanent Magnets of Sintered Oxides. R. J. Studders, *Product Engr., 19,* No. 2, 120-122 (1948). A typical composition is 31% Fe_2O_3, 43% Fe_3O_4 and 26% CoO. The magnets have intense energy levels, high electrical resistivity, and strongly resist demagnetizing forces. Details of physical, electrical, magnetic properties and design data are given.

(3779) Report of Properties of Sintered Alloys for Permanent Magnets. W. Zumbusch, *Z. angew. Physik, 1,* No. 1, 45-47, 98-104 (1948). The system Fe-Ni-Al with additions of Ti and Co is investigated.

(3780) Permanent Magnets. A. Edwards, *Electrician, 142,* 1567-71 (1949). Improvements in the field of permanent magnets during the past thirty years. Review includes sintered products.

(3781) Magnetic Properties and Applications of Permanent Magnets from Powdered Metals. H. Fahlenbrach, *Arch. Eisenhüttenwesen, 20,* No. 9/10, 201-4 (1949). Effects of porosities and inclusions on alloys containing 12-33% Ni, 5-14% Al, 5-20% Co, 0-12% Ti, 0-6% Cu, balance Fe; microstructures and magnetic characteristics; photographs, graphs.

(3782) Permanent Magnets from Powders. R. A. Hetzig, *Iron & Coal Trades Rev., 157,* 1474 (1949). A summary of various British patents and patent applications on colloidal powders and iron oxide powders, with an indication of the single-domain theory.

B. Soft magnetic iron parts

(3783) Hydrogenized Iron. P. P. Cioffi, *Phys. Rev., 39, Ser. 2,* 363-67 (1932). The magnetic properties of soft iron are described.

(3784) W. S. Messkin, and A. Kussmann, *Die ferromagnetischen Legierungen.* Springer, Berlin, 1932. A broad treatment of soft magnetic materials based on iron is presented. Alloys discussed include those of iron with nickel, cobalt, silicon and molybdenum.

(3785) Technical Materials of Great Magnetic Softness. F. Stäblein, *Z. tech. Physik, 13,* 532-34 (1932). Tests with the ballistic galvanometer on pure sintered iron-nickel alloys from carbonyl powders to measure small coercive forces are described. A comparison is made with silicon-bearing special soft iron.

(3786) O. Buddenberg, F. Duftschmid, and L. Schlecht, *Festschrift zum zehnjährigen Bestehen der Firma Heraeus Vakuumschmelze.* Albertis, Hanau, 1933. Magnetic iron and nickel alloys and preparation of iron powder are treated on pp. 74-80.

(3787) A New Process for the Commercial Production of Nickel. G. Hamprecht, and L. Schlecht, *Metallwirtschaft, 12,* No. 1, 281-84 (1933). Permeability curves are given for different sintered carbonyl nickel-iron alloys.

(3788) New High Permeabilities in Hydrogen Treated Iron. P. P. Cioffi, *Phys. Rev., 43,* No. 2, 742-44 (1934). Maximum permeability values of iron are reported for metal of the highest purity that is annealed in hydrogen.

(3789) Status of Research and Development in the Field of Ferromagnetic Materials. A. Kussmann, *Arch. Elektrotech., 29,* No. 5, 297-332 (1935). A review covering soft magnetic materials based on pure iron is given.

(3790) Ways and Results of Research on Ferromagnetic Materials. A. Kussmann, *Z. Ver. deut. Ing., 83,* No. 16, 445-56 (1939). Work on soft magnetic materials, *e.g.,* pure iron and alloys of iron, is discussed.

(3791) Materials for Special Electrical Purposes. F. H. Clark, *Metals & Alloys, 21,* No. 1, 108 (1945). Part of "Materials for Solving Specific Engineering-Service Problems," a group of articles. Includes description of pole pieces made by powder metallurgy.

(3792) Molding, Sintering of Complex Magnetic Parts Significant. C. G. Goetzel, *Steel, 116,* No. 1, 278 (1945). Production of pole pieces from pure, carbon-free iron powders described.

(3793) Powder Metallurgy Precision Parts. R. Hradecky and R. P. Seelig, *Iron Age, 156,* No. 13, 50-54, 132 (1945). Development of new sintered soft

magnetic iron described and coercive force and maximum permeability plotted ("Pomet-300").

(3794) Pole Pieces for Electric Motors Made from Iron Powders. F. V. Lenel, *Trans. Am. Inst. Mining Met. Engrs., 161,* 535-541 (1945). Method of manufacture, design possibilities, and properties of pole pieces for direct-current electric motors and generators made from Fe powder. Discussion by R. P. Seelig.

(3795) Pressing Complicated Shapes from Iron Powder. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 166,* 506-519 (1946). Pressing of curved and stepped soft-magnetic parts, such as pole pieces and armatures. Discussion.

(3796) High Magnetic Permeability of Powder Iron Components. D. A. Oliver, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 63-66; *Met. Powd. Rept., 1,* 63-66; No. 11, 166 (1947). The possibilities of sintered magnetic iron components, *e.g.*, pole pieces, are being explored.

(3797) Some Properties of Iron-Silicon Alloys from Powders. R. Steinitz, *Powd. Met. Bull., 2,* No. 6, 135-137 (1947). Addition of Si applied to iron by powder metallurgy methods in production of soft magnetic parts. 15% ferrosilicon powder is abrasive and hard on the dies, but in amounts to yield 4-6% Si in final alloy is compactible.

(3798) Report on the Investigations of Ferromagnetic Mn-Al-Fe-C Alloys. F. D. Rept. No. 613/48 (1948). A three-page translation of a German report (origin unknown) on an alloy with the composition 70% Mn, 13.3% Al, 5.36% C, 12.1% Fe and 0.3% P as impurity. Said to have excellent soft magnetic properties and to be very cheap when manufactured from ferromanganese and aluminum remolten scrap.

(3799) Magnetic Properties of Iron Compacts in Relation to Sintering Temperature. R. Steinitz, *Met. Powd. Rept., 2,* No. 12, 190 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 195 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 58. Four different oxide-reduced powders were used, with similar particle characteristics. The permeabilities differed widely; in one case sintering at 1250° C. (2280° F.) gave a permeability of 3100, compared with 1600 at 1150° C. (2100° F.).

(3800) Magnetic Properties of Iron Powder Compacts. R. Steinitz, *Trans. Am. Inst. Mining Met. Engrs., 175,* 834-847 (1948). Raw materials have negligible influence on magnetic properties, if these are compared for identical densities and not for identical processing procedures. Influence of sintering temp. on magnetic properties. Coercive force higher, residual magnetism and permeability lower for porous materials than for Armco iron.

(3801) Magnetic Properties of Sintered Iron. W. Rostoker, *Trans. Am. Inst. Mining Met. Engrs., 180,* 672-693 (1949). Low porosity can be produced by the diffusion-alloying of elemental powders; these alloys possess good magnetic properties; diffusion alloying technique used to produce alloys in suitable forms; Fe-Co alloys are susceptible to heat-treatment.

C. High frequency cores and magnetic products of controlled permeability

(3802) Some Notes on the Theory of the Telephone and on Hysteresis. O. Heaviside, *The Electrician, 18,* 302-303 (1886/1887). A suggestion is made that a core be constructed of finely divided iron insulated with wax.

(3803) Magnetic Cores. E. Gumlich, *Elektrotech. Z., 42,* 1494-95 (1921). The use of iron powder for this application is described.

(3804) Magnetic Properties of Compressed Powdered Iron. B. Speed, and G. W. Elmen, *J. Am. Inst. Elec. Eng., 40,* 596-609 (1921). New magnetic material for transformer coils for telephone plant, material fine grained.

(3805) Permalloy, an Alloy of Remarkable Magnetic Properties. H. D. Arnold and G. W. Elmen, *J. Franklin Inst., 195,* 621-27 (1923). The behavior of Permalloy demonstrates that ferromagnetism is associated with material structure in a different way than are the ordinary physical properties.

(3806) Magnetic and Electrical Properties of Iron and Its Alloys. O. v. Auwers, *Gmelins Handbuch der anorganischen Chemie, Eisen, Syst. - No. 59, A,* Berlin, 1927/33, pp. 1451-52, 1468, 1477, 1505, 1512 (1927/33). Investigations are reported on the effect of the degree of densification and particle size on the magnetic properties of compressed iron powder compacts for cores.

(3807) Compressed Powdered Permalloy. W. J. Shackleton, and I. G. Barber, *Trans. Am. Inst. Elec. Eng., 47,* No. 2, 429-39 (1928). Production and properties of magnetic cores from Permalloy powder

(3808) Magnetic Alloys of Iron, Nickel and Cobalt. G. W. Elmen, *J. Franklin Inst., 207,* 583-617 (1929). Further development of alloys of the Permalloy type led to the development of nickel-iron alloys containing small percentages of other elements.

(3809) Development in Tuning Coils. H. Vogt, *Wireless World, 31,* 272-73 (1932). An account is given of a new material called "Ferrocart," containing carbonyl iron powder, and used in the construction of magnetic cores.

(3810) Cores for Coils. *Wireless Eng., 10,* 1 (1933). Iron powder compound cores for coils; effective permeability; losses in cores.

(3811) Pure Carbonyl Iron as a Magnetic Material. O. Buddenberg, F. Duftschmid, and L. Schlecht, *Heraeus Vakuumschmelze Festschrift,* 74-80 (1933). Discussion of pure iron as a high permeability magnetic material.

(3812) Iron Core Intermediate Frequency Transformers. A. Crossley, *Electronics, 6,* No. 11, 298 (1933). The article describes certain phases of the application of a special iron developed by Polydoroff.

(3813) Iron Powder Compound Cores for Coils. G. W. O. Howe, *Wireless Eng., 10,* No. 112, 1-4 (1933). Effective permeability; losses in the cores are surveyed.

(3814) Ferrocart; Losses in Radio Frequency Magnet Cores. A. Schneider, *Electrician, 110,* No. 2874, 849-850 (1933). There are five sources of losses described: (*1*) Hysteretic; (*2*) eddy current; (*3*) galvanic eddy current; (*4*) capacitive eddy current; (*5*) dielectric losses.

(3815) Iron Content Cores for High-Frequency Coils. A. Schneider, *Wireless Eng., 10,* 183-5, 293-5, 313-5, 491-2 (1933). Use of Ferrocart; the insulated iron particles, having a shape similar to an ellipsoid and being of small size, are arranged in a very thin layer on an insulating paper strip, on which small channels are made, to sub-divide the layer into small strips.

(3816) Metals in the Electric Industries. C. J. Smithells, *Iron & Steel Ind., 6,* 327-30 (1933). Use of powdered Fe-Ni Alloys for transformer cores are described.

(3817) Magnetic Materials. W. C. Ellis, and E. E. Schumacher, *Metals & Alloys, 5,* 269-76 (1934). Summary of properties of large number of alloys for magnetic purposes including those in powdered form.

(3818) Further Notes on Iron-Core Coils. W. J. Polydoroff, *Electronics, 7,* No. 1, 13-14 (1934). The application of iron in high frequency coils is of a particular interest if the inductance must be confined to a small space, as in radio receivers.

(3819) Ferrocart Coils; Their Application in High-Frequency Technique. A. Schneider, *Electrician, 113,* No. 2950, 770-2 (1934). Although the magnetic particles are all insulated from each other by a skin, it is found that apparently small eddy currents are still continuing over the core structure.

(3820) Survey of Magnetic Materials in Relation to Structure. W. C. Ellis, and E. E. Schumacher, *Bell System Tech. J., 14,* No. 1, 26-9 (1935). Among other subjects: magnetic alloys in dust form.

(3821) Iron Cores for Radio Coils. *Wireless Eng., 13,* No. 152, 235-6 (1936). A mixture of iron powder and insulating material can be made in several ways; the best results are obtained by pressing into a mold, to approach the toughness of cast iron.

(3822) The Manufacture of Compressed Powdered Cores. T. Aizawa, and G. Sadkiyo, *Nippon Elec. Commun. Eng.* Special Number, Dec. 1936, pp. 455-7 (In English). By using "Sendust" granules smaller than 250 mesh the dust cores have permeabilities of 50 to 60. The specific gravity of the alloy is 6.92, and of compressed powdered cores 5.4-5.6.

(3823) Properties of Magnetic Cores. O. v. Auwers, *Gmelins Handbuch der anorganischen Chemie, Syst. - No. 59, D,* Berlin, 1936, pp. 433-437; 1937, pp. 135-136, 140. Pressed iron particles individually insulated are described as useful material for magnetic cores.

(3824) High-Frequency Magnetic Materials. H. Crowley, *Radio Engr., 16,* No. 10, 15-16 (1936). The problem of providing a thin insulating film around each particle, strong enough to withstand pressures, proved to be rather difficult from a manufacturing viewpoint.

(3825) Magnetic Materials at Radio Frequency. Dept. of Scientific and Industrial Research, *Radio Res. Special Report No. 14* (1936). A critical survey of the magnetic core field.

(3826) Magnetic Measurement of Low Flux Densities Using the Alternating Current Bridge. V. E. Legg, *Bell System Tech. J., 15,* 39-62 (1936). Calculations were made of the core loss of a dust core and sheet magnetic material at low flux densities.

(3827) On a New Alloy "Sendust" and Its Magnetic and Electrical Properties. H. Masumoto, *Science Repts. Tohuku Imp. Univ., Honda Anniv. Volume,* pp. 388-398 (1936). Ternary alloys of iron with small amounts of silicon and aluminum have been reported to be of interest for magnetic powder. These alloys are characterized by high magnetic quality and intrinsic brittleness.

(3828) Study of Dust Core for High Frequency Coils. S. Sanehudi, *J. Inst. Elec. Engrs. Japan, 56,* 95 (Engl. Abstr.) (1936). Iron particles were insulated by various methods and compressed; the specific gravity of the compressed iron was 4 to 5.3, the permeability 10 to 30, while permeability of non-insulated powder was 50.

(3829) Use of Loading Coils in the Telephone Industry. W. Six, *Philips Tech. Rev., 1,* 353-61 (1936). Suppression of eddy currents in iron cores is investigated.

(3830) Magnetic Cores for Loading Coils. J. L. Snoek, *Philips Tech. Rev., 2,* 77-83 (1937). Review, including cores from compressed powders.

(3831) Report on the Research Committee Meeting on Materials for Communication Equipment. *Dinki Tsushin Gakukai Shi, 181,* 54-64 (1938). Review including powdered Permalloy for cores.

(3832) Distribution of Magnetic Flux in an Iron Powder Core. *Wireless Eng., 15,* No. 180, 471-2 (1938). The problem can be idealized by assuming the iron particles to be cubes of the same size, arranged uniformly with their faces either parallel or normal to the magnetic flux.

(3833) Some Notes on Iron Dust Cored Coils at Radio Frequencies. C. Austin, and A. L. Oliver, *Marconi Rev., 70,* 17-31 (1938). Advantages and disadvantages of various shapes of cores are compared, and a method of inductance adjustment is noted. Consideration to winding desiderata and screening losses.

(3834) Iron Powder Cores, Their Use in Modern Receiving Sets. E. R. Friedländer, *Wireless Engr., 15,* No. 180, 473-9 (1938). The use of iron cores in U.S. is far below that in other countries and the reason for this is discussed; a review of the development of mass cores is given.

(3835) Iron Cores. J. Hak, *Rev. Gen. Electr., 43,* 35-38 (1938). HF resistance of powdered iron cores.

(3836) Magnetic Materials. V. E. Legg, *Bell System Tech. J., 18,* 438-39 (1939). Survey of magnetic materials and applications in telephone systems; loading coils are made by compressed powdered Permalloy.

(3837) Magnetically Soft Materials. T. D. Yensen, *Trans. Am. Soc. Metals, 27,* 797-820 (1939). Permalloy and other high permeability alloys in form of powder, first insulated, and then compressed into doughnut shaped cores, and finally annealed are discussed.

(3838) Compressed Powdered Molybdenum-Permalloy for High-Quality Inductance Coils. V. E. Legg, and F. J. Given, *Bell System Tech. J., 19,* 385-406 (1940); *Bell Tel. System, Tech. Pub. Monographs,* 1940, B 1243. 2-81 Mo-Permalloy containing 2% Mo, 17% Fe and 81% Ni is compared with regular powdered Permalloy containing 21.5% Fe and 78.5% Ni.

(3839) New Magnetic Alloy of Powdered Metal. V. E. Legg, and F. J. Given, *Metal Progress, 38,* No. 3, 284, 304-05 (1940). Extracts from "Compressed Powdered Mo-Permalloy for High-Quality Inductance Coils" *Bell System Tech. J., 19,* 385-406 (1940).

(3840) Compressed Powdered Molybdenum Permalloy. V. E. Legg, and F. J. Given, *Trans. Am. Inst. Elec. Engrs., 59,* 865-72 (1940). The same general principles that were used for making 80% nickel-iron dust cores were applied to making cores of 2-81-17 Mo-Ni-Fe. High permeability and low losses make possible improved coil quality or decreased size.

(3841) Measurement of Iron Cores at Radio Frequencies. D. Foster, and A. E. Newlon, *Proc. Inst. Radio Eng., 29,* 266-270 (1941). Theoretical considerations, method of measurement, effect of the core on coil Q-value, and description of tested cores are presented.

(3842) Optimum Damping of Iron Core Radio Coils. J. Labus, *Hochfrequenz-technik u. Elektroakustik, 57,* No. 4, 112-4 (1941). The maximum of the quality index of iron core coils is independent of the form and the size of the core and the coils.

(3843) Magnetic Cores. K. Sixtus, *Feinmechanik Präzision, 49,* 139-145, 153-160 (1941). The form and shapes as related to the service conditions are discussed.

(3844) Radio Uses of Powdered Iron Cores. *Electronics, 15,* No. 2, 35-7, 93-5 (1942). Loop antennas of reduced size by powder metallurgy; other uses described.

(3845) Optimal Damping of Cores. *Elektrotech. Z., 63,* 144 (1942). The maximum value of the quality factor "Q" is determined mathematically.

(3846) New Findings in the Field of Magnetic Cores. G. Kiessling, and O. Ludl, *Elektrotech. Z., 63,* 413-16 (1942). A review of up-to-date developments, especially in Germany.

(3847) High-Frequency Iron Cores, Part II. A. C. Lescarboura, *F. M. Radio-Electronic Engineering & Design, 2,* No. 9, 7; No. 11, 6 (1942). Characteristics of specific powdered Fe core materials at frequencies up to 50 megacycles discussed.

(3848) Optimum Damping of Coils with Compressed Powder Cores. G. Lohrmann, *Hochfrequenztechnik u. Elektroakustik, 59,* No. 5, 150-1 (1942); *Wireless Engr., 19,* No. 231, 571-572 (1942). Lohrmann compares the formulas obtained by J. Labus, *Hochfrequenztechnik u. Elektroakustik, 57,* No. 4, 112-114 (1941), with those of his own paper and finds that the important ones are identical.

(3849) Powdered Iron Makes Superior Cores for Radio Transformers. A. B. Mullaly, *Metal Progress, 42,* No. 4, 735 (1942). Iron cores, replacing iron rods and filings, enable the redesign of intermediate frequency transformers into efficient small sized assemblies of coil and iron core; also permit permeability tuning, a system of moving iron cores inside tuning coils; also are significant by causing reduction in radio transformer size and copper requirements.

(3850) Magnetic Powders and Production of Cores for Inductance Coils. E. E. Schumacher, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 14, pp. 166-172. Preparation of brittle alloy, pulverization, insulating and pressing.

(3851) Powdered Iron Cores. A. Crossley, *J. Applied Phys., 14,* No. 9, 451-55 (1943). Use of powdered iron cores. 3 main advantages cited: (*1*) increase of inductance with increased efficiency: (*2*) tuning or coupling changes in circuits

by movement of iron core; (3) increase in signal voltage in loop antennas by increase in permeability of medium.

(3852) Dust Cored Coils. V. Welsby, *Electronics Eng., 16,* 96, 149, 191, 230, 281 (1943). Development of dust core material. Analysis of losses. Variation of Q with frequency. Equi-Q charts. Methods of measurement.

(3853) Magnetic Dust Cores. G. R. Polgreen, *Post Office Elec. Engrs. J., 37,* 1-6 (1944). Information is given on the production of alloy dust cores.

(3854) Radio Frequency Cores of High Permeability. H. Beller, and G. O. Altmann, *Electronic Ind., 4,* No. 11, 86-89, 152, 154 (1945). Cores made from a special grade of carbonyl Fe powder to meet the demand for powdered magnetic cores combining both higher permeability and low losses at frequencies up to several megacycles.

(3855) Magnetic Stability of Torroidal Cores. B. Ferrtachak, *Rev. Gén. Electricité, 54,* No. 3, 79-88 (1945). Analysis of aging phenomena and their causes and characteristics, particularly in case of iron powder cores.

(3856) Magnetic Materials. H. Lacoste, *Metallurgie et Construction Mecanique, 77,* No. 5, 5-6, 16 (1945). Magnetic materials including powdered alloys for cores discussed.

(3857) Powdered Iron Cores. C. T. Martowicz, *Electronics Ind., 4,* 108-110 (1945). Design factors that influence realization of the superior electrical characteristics of iron cored coils.

(3858) Magnetic Powders for Cores. H. G. Shea, *Electronic Ind., 4,* No. 8, 86-89, 189, 190, 194, 198, 202 (1945). Many physical and chemical characteristics bear on usefulness of metallic and compound iron powders. Magnetic testing. Carbonyl powders. Photomicrographs. Samples of various types of radio cores.

(3859) Iron Dust Core Coils. *Brown Boveri Rev., 33,* 219 (1946). Dimensions, properties and advantages of powdered iron cores discussed.

(3860) Iron Cores – Proposed Test Coils. *Electronic Inds., 5,* No. 1, 71 (1946). Tentative standards for testing permeability and Q of powdered iron core slugs 3/8 in. in diameter and 3/4 in. long. Table shows characteristics of coils.

(3861) Lutz and Co., Lauf. S. J. Borgars, C.I.O.S. Rept. No. XXIX-31 (1946). In addition to dust cores, this firm made a magnetic ceramic of 85/15 magnetite and steatite. Magnesium carbonate may also have been added. This is of interest in the centimeter wave band and for coating submarines and aircraft as anti-radar protection.

(3862) Permeability of Iron Dust Cores. G. W. O. Howe, *Wireless Engr., 23,* 291-92 (1946). A discussion is given of the calculation of dust-core permeability from the inherent properties of the material.

(3863) Powdered Iron Cores. C. T. Martowicz, *Steel, 118,* No. 13, 146-48 (1946). Characteristics of electrical-grade iron powders make them suited for use in high-frequency magnetic application.

(3864) Non-Metallic Magnetic Material. J. L. Snoek, *Philips Tech. Rev., 8,* No. 12, 353-60 (1946); *Met. Powd. Rept., 1,* No. 12, 190 (1946). Applications are for cores for H. F. transformers, telephone band pass filters, and permeability tuning devices. The non-magnetic ferrite must have a tetrahedral arrangement of the ferric ions, which limits choice to zinc ferrite and cadmium ferrite. "Ferroxcube" parts are made by pressing dry powder in steel molds mixed with a plastic binder, and sintering at 1000-1400° C. (1830-2550° F.). Very high resistivity gives negligible eddy current losses.

(3865) A New Magnetic Material of High Permeability. O. L. Boothby, and R. M. Bozorth, *J. Applied Phys., 18,* No. 2, 173-5 (1947). Supermalloy is composed of 79% Ni, 5% Mo, 15% Fe, 0.5% manganese; has a permeability of 600,000-1,200,000; a coercive force of 0.002-0.005; Curie point of 400.

(3866) Nickel-Iron Dust Cores. S. E. Buckley, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, Special Rept. No. 38, London (1947), pp. 59-62; *Met. Powd. Rept., 1,* No. 11, 165-6 (1947). Author outlines development of Mo-Permalloy type cores and discusses the constancy of permeability and influence on design.

(3867) Iron Cores. F. R. Hensel, F.I.A.T. Rept. No. 792, 15 pp.; *Met. Powd. Rept., 1,* No. 7, 106-107 (1947). A description is given of the multitude of processes of manufacture of cores at the three principal German firms in this field, Siemens & Halske, A. E. G., and Vogt. The report places special emphasis on insulation and bonding of low hysteresis iron and iron-nickel powder cores.

(3868) Iron Core Technique. G. Kiessling, and O. Ludl, *Elektrotech. Z., 63,* No. 35/36, 413 (1947). Recent developments in iron core techniques with special reference to radio and telephone applications. Production of Fe powder also discussed.

(3869) German Methods for Manufacture of Iron Powder Cores. H. L. Krebs, U. S. Dept. Comm., PB. 78996, 1947, 15 pp. The carbonyl iron powders used in Germany are of better quality than American powders. Mixing and insulating material is different although the same components are used. Seven German carbonyl Fe powders are listed.

(3870) Telephone Cable with Ferromagnetic Powder Filling. Metallgesellschaft A. G., F. D. Rept. No. 4875/47 (1947). Reports, dated 1937-38, deal with the chemical properties of magnesia, alumina, etc. as insulating material. It was thought that coating of the core metal with carbonyl iron powder would increase the inductance, but manufacturing difficulties had so far prevented the testing of such cables. A complete carbonyl iron powder core also seemed to be feasible.

(3871) The Nature, Properties, and Applications of Carbonyl Iron Powder. L. B. Pfeil, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, London, Special Rept. No. 38, 47-51 (1947). The applications of carbonyl iron powder in the magnetic core field are surveyed.

(3872) Comparison of Magnetic Powder Cores for High and Low Frequencies. G. R. Polgreen, *Symposium on Powder Metallurgy.* The Iron and Steel Institute, Special Rept. No. 38, London, pp. 52-58 (1947); *Met. Powd. Rept., 1,* pp. 52-58 (1947). For a low frequency, Permalloy has a permeability at least twice that of iron, while in the medium frequency range the high Ni-Fe alloys give the lowest losses.

(3873) J. L. Snoek, *New Developments in Ferromagnetic Materials.* Elsevier, New York-Amsterdam, 1947. Research with ferrites of the type MFe_2O_4, called Ferroxcube, with M denoting a bivalent metal, is discussed within the framework of a theoretical and practical treatment of this new field of non-metallic magnetic materials development for high frequency core applications.

(3874) A New Magnetic Material of High Permeability. *Bell Laboratory Records, 26,* No. 3, 111-12 (1948). A description of Mo-Permalloy is given.

(3875) Properties of Insulating and Magnetic Material. *Product Engr., 19,* No. 3, 147-48 (1948). From symposium of conference papers on materials presented at Am. Inst. Mining Met. Engrs., Winter Meeting, 1948: "Titanate Dielectrics" by G. R. Shelton. "Special Magnetic Alloys" by G. W. Elmen and E. A. Gangler.

(3876) A New Magnetic Material of High Permeability. O. L. Boothby, and R. M. Bozorth, *Bell Tel. System, Tech. Publ. Monograph,* B1451 (1948). Description of Supermalloy, a powdered alloy containing 0.5% Mn, 5% Mo, 15% Fe, balance Ni.

(3877) German Methods for Iron Powder Cores. H. L. Krebs, F.I.A.T. Rept. No. 1101, 15 pp.; *Powd. Met. Bull., 3,* No. 1, 10-14 (1948). Manufacturing German methods are similar to those used in U.S. but German produced better results. Starting material was carbonyl iron powder of I.G. Farben, Vogt & Co., Erlau, R. Bosch, Siemens & Halske, Meitlingen. U.S. Dept. Comm. PB. 78996.

(3878) Magnetic Powder Cores. G. R. Polgreen, *J. Inst. Elect. Engrs., 95,* Pt. I, No. 96, 540-43 (1948). Technical advantages; design advantages; improvement in magnetic materials; extension and application of powder cores; permanent magnets.

(3879) Iron Powder in Electronics. E. F. Swazy, L. S. Busch, and A. M. Suggs, *Proc. Fourth Ann. Spring Meeting Met. Powd. Assoc.,* Chicago, April 15-16, 1948, pp. 51-69. Prerequisites of the material for iron cores. Materials and

methods for their manufacturing. Screen analysis and apparent density for H reduced iron powder. Pressing equipment.

(3880) Iron Cored D.F. Loops and Manufacture of Iron Dust. K. F. Umplby, F. G. Overbury, and G. R. Polgreen. B.I.O.S. Final Rept. No. 1203, 31 pp.; *Met. Powd. Rept., 1,* No. 9, 133 (1948). Report deals with: (*1*) magnetic materials by Siemens and Halske in production of direction-finding loops for aircraft, and (*2*) production of carbonyl iron powder at I.G. Farbenindustrie A.G. (*cf.* F.I.A.T. Rept. No. 792).

(3881) Sintered Iron Cores. Vereinigte Deutsche Metallwerke. F.D. Rept. No. 3537/48 (1948) (formerly H.E.C. 12634). Correspondence on the filing of patent applications for sintered iron bullet cores, 1940-44.

(3882) Television Parts Made by Powder Metallurgy. *Iron Age, 163,* No. 12, 74 (1949). The Radio Corporation of America is making daily 5,000 core assemblies, each weighing 1 1/3 lb., the two frames being made from sponge iron powder, and the center slug from electrolytic iron powder. The cost is 55-60¢ each, compared with $3.00 for laminated cores.

(3883) Nonmetallic Materials Developed with Improved Magnetic Properties. *Materials and Methods, 29,* No. 6, 54-55 (1949). A review on sintered ferrites, with some data on their properties and uses in communication equipment.

(3884) Soft Magnetic Materials. E. A. Gangler, *Product. Eng., 20,* No. 7, 84-89 (1949). Contains a table with typical magnetic properties. Pressed powder cores are included in discussion.

(3885) A Survey of Applications of Ferrites. K. E. Latimer, and H. B. MacDonald, *Symposium on Ferromagnetic Materials,* Institution of Electrical Engineers, Nov. 7-8, 1949; *Met. Powder Rept., 4,* No. 4, 59 (1949). The paper gives data on properties and applications that have so far materialized for high-frequency transformers and filter coils.

(3886) Some Properties and Tests of Magnetic Powders and Powder Cores. C. E. Richards, S. E. Buckley, P. R. Bardell, and A. C. Lynch, *Symposium on Ferromagnetic Materials,* Institution of Electrical Engineers, Nov. 7-8, 1949; *Met. Powder Rept., 4,* No. 4, 59-60 (1949). Various methods of powder manufacture and application of different pressures in making cores are described. Six different methods of calculating core losses are discussed, and a breakdown of the combined core and coil losses into the individual losses is made. The properties of the various magnetic materials are tabulated.

(3887) Deltamax, a New Magnetic Core Material. W. S. Spring, *Iron Age, 163,* No. 13, 70-73 (1949). The production and use of the nickel-iron alloys is described.

(3888) Iron Carbonyl Powder. P. H. Vogel, and E. F. Eckert, U. S. Dept. Comm. P. B. 97775, *Bibl. Tech. Rept., 12,* No. 5, 179 (1949). A carbonyl iron powder with a particle size of 0.25-3.5 microns has been developed in Germany for magnetic cores.

5. FERROUS MATERIALS AND PRODUCTS

(3889) Physical Properties of Parts made from Iron Powder. C. G. Goetzel, *Proc. Second Ann. Spring Meeting Metal Powder Assoc.,* New York, June 13, 1946, pp. 73-79. History of production, methods to obtain higher physical properties in Fe powder products. Comparative data, physical properties of cemented steel and those of carbon-free cemented iron.

(3890) Materials and Methods Manual 22, Parts and Metal Forms, Powder Metallurgy. *Materials & Methods, 25,* No. 1, 94, 100 (1947). Developments during 1946: copper-infiltrated iron and steel ("Sinteel G") SAE 1112 steel chips used to make parts by powder metallurgy; use of ultra-fine metal powders for high-density parts produced at low pressures; carbursintering; stainless steel parts.

(3891) Improved Engineering Properties of Parts Made from Iron Powders. C. G. Goetzel, *Product Eng., 18,* No. 8, 115-9 (1947). Data regarding attempts to improve physical properties by the reduction of residual porosity. Marked improvement has resulted from filling the pores to reduce the porosity, rather than from application of high pressures; use of Cu alloys for infiltrating the pores. Cu and Fe alloying; heat treatment of iron powder products.

(3892) R. Kieffer and W. Hotop, *Sintereisen und Sinterstahl,* 1948, Springer, Vienna, 556 pp. Raw materials and processes in iron powder metallurgy; description of methods of producing iron powders and their properties, pressing and sintering and properties of compacts, multiple pressing and sintering, hot pressing, pressing and sintering apparatus. Sintered iron and steel as material of construction. Properties of sintered *vs.* cast and wrought materials; porous ferrous materials; finished structural parts for machine and apparatus construction; industrial applications including components for vacuum technique, permanent magnets and soft magnetic parts, cores, corrosion and heat resistant alloy products. Sintered iron alloys.

(3893) Electrolytic Iron Powder. *Mech. World, 125,* No. 3238, 115-6 (1949). Its use in powder metallurgy; for production of iron powders, electrolytic method has proved successful in that it yields powder of high degree of purity; this feature makes for higher efficiency, not only when powder is worked alone, but also when other ingredients have to be incorporated.

(3894) Fatigue Strength of Sintered Iron Products. M. Hempel and H. Wiemer, *Arch. Metallkunde, 3,* No. 1, 11-17 (1949). Experimental data are presented in form of tables and charts, showing the effects of initial particle size and density.

A. Iron and carbon steels (machine parts, dense bearings)

(3895) F. Ullmann, *Enzyklopädie der technischen Chemie,* 2nd Ed., Urban & Schwarzenberg, Berlin-Vienna, 1929. In Volume 4, pp. 210-211, the prehistoric methods of producing massive iron from powder or sponge are described.

(3896) O. Johannsen, *Geschichte des Eisens,* Verlag Stahleisen, Düsseldorf, 1925. On pp. 6-7, the prehistoric techniques of producing compact iron objects from iron powder or sponge are described. On p. 11, large structural members built from compacted iron in the Middle Ages in India are discussed. On p. 23, the use of carbon-containing iron powder for weapons and utensils in ancient history is described.

(3897) The Metallography of Some Ancient Egyptian Implements. H. C. H. Carpenter, and J. M. Robertson, *J. Iron Steel Inst., 121,* 417-448 (1930). An investigation is made of the structure of the low-temperature charcoal-reduced, carbon-free and forgeable iron lumps found at Ninive.

(3898) Reason for the Abnormal Behavior of Steels by Case Hardening. F. Duftschmid, and E. Houdremont, *Stahl u. Eisen, 51,* 1613-1616 (1931). Carbonyl and electrolytic iron powder for production of steel by powder metallurgy are included in the discussion.

(3899) Strengthening of Powdered Carbonyl Iron by Pressing and Heating. L. Schlecht, W. Schubardt, and F. Duftschmid, *Z. Elektrochem., 37,* 485-92 (1931). Pure iron produced by sintering is very soft, but has the same deep drawing quality as copper; its strength is the same as that of fused iron.

(3900) The Technical Treatment of Powdered Carbonyl Iron According to the Sintering Method. F. Duftschmid, L. Schlecht, and W. Schubardt, *Stahl u. Eisen, 52,* No. 2, 845-49 (1932). Physical and chemical reactions during the sintering. Practicability of the sintering. Use of carbonyl iron.

(3901) Powdered Metals. J. W. Weitzenkorn, *Metal Progress, 22,* No. 2, 52 (1932). Powder metallurgy in iron and steel will receive impetus when cheap iron powder and alloying metal are assured in commercial quantities.

(3902) Note on Sponge Iron and Powder Metallurgy. E. F. Cone, *Iron Age, 133,* No. 6, 30 (1934). A large automobile manufacturer is using sponge iron to produce parts; imports of Swedish sponge iron showed notable gains.

(3903) Ferrous Powder Metallurgy — A Survey of Developments in Powder Metallurgy as It Applies to Ferrous Materials. C. Hardy, *Steel, 95,* No. 20, 52-53 (1934). Control of grain size and structure. Selection of the type of carbon mixed with Fe. Ni powder for coating of welding rods.

(3904) Nitrogen Content and Normal Structure of Sintered Carbonyl Steels. H. Cornelius, and H. Esser, *Arch. Eisenhüttenwesen, 9,* No. 7, 367-68 (1936). Tests with steels containing different amounts of C. N content has no influence on the formation of normal structures during case hardening.

(3905) W. Espe and M. Knoll, *Werkstoffkunde der Hochvakuumtechnik.* Springer, Berlin, 1936. A discussion of the production of pure iron for use in vacuum technique is on p. 59ff.

(3906) On the Production and Properties of Steel from Carbonyl-Iron. E. K. Offermann, *Mitt. Kohle- u. Eisenforsch. Ver. Stahlwerke, Dortmund, 1,* No. 5, 85-120 (1936). Investigation of whether the sintering process can be used for steel production. Sintering produces sound ingots when the temperature is not lower than 1000° C. (1830° F.). The pure iron contained up to 0.03% C., 0.015% O, 0.022% N.

(3907) The Production and Properties of Steel Made from Carbonyl Iron. E. K. Offermann, H. Bucholtz and E. H. Schulz, *Stahl u. Eisen, 56,* 1132-38 (1936). Production of pure iron and plain carbon steel from carbonyl iron powder by sintering. Zone formation and its avoidance in sintering carbon steels. Comparison of the properties of carbonyl iron and steel with melted steels.

(3908) Powder Metallurgy of Iron with Particular Reference to Pacteron. W. D. Jones, *Foundry Trade J., 59,* 401-02 (1938); *Iron & Coal Trades Rev., 137,* 1013-14 (1938). Review of development, application and properties of "Pacteron," a cast iron base composition made by powder metallurgy (hot pressing); the hard cast iron particles are cemented together by an iron-iron phosphide eutectic alloy, and the resulting material has remarkably high tensile strength.

(3909) Properties of Mild Steel Made from Sponge Iron. K. Kusaka, *Tetsu-to-Hagane, 24,* 281-5 (1938). Higher weldability and toughness.

(3910) Porous Cast Iron Made from Powder. M. Yu. Bal'shin and N. G. Korolenko, *Vestnik Metalloprom., 19,* No. 3, 34-44 (1939). *Cf. Metallurgia, 22,* No. 128, 59-61 (1940).

(3911) Some Observations on Iron Powder Metallurgy. G. J. Comstock, *Iron Age, 143,* No. 22, 40-41, 64 (1939). Swedish situation of iron products. Objects of sponge iron can be molded economically; porous iron bearings depend on the cost of iron powder and on the efficiency of the manipulations.

(3912) Influence of Sintering Time, Temperature and Pressure on the Tensile Properties of Sintered Iron. W. Eilender and R. Schwalbe, *Arch. Eisenhüttenwesen, 13,* No. 6, 267-272 (1939). Iron powder used was coarser than that used by F. C. Kelley, *i.e.*, 50 mesh; pressure was increased to 70 tsi; sintering temperature was raised to 1200° C. (2200° F.). Both tensile strength and elongation were substantially increased by raising the sintering temperature.

(3913) Powder Metallurgy of Iron. W. D. Jones, *Metal Ind. (London), 54,* 51-55 (1939). Particular reference is made to "Pacteron." *Cf. Foundry Trade J., 59,* 401-402 (1938).

(3914) Sinterloy Powder Pressed. *Am. Machinist, 84,* No. 6, 188-9 (1940). "Sinterloy" products may be pressed directly into shape of the finished product, to eliminate machining costs.

(3915) Gears of Iron Powder. *Automotive Ind., 82,* No. 4, 158-59 (1940). The material cuts the costs of manufacturing; the products are held within close tolerances.

(3916) Researches of Mellon Institute 1939/1940: Electrolytic Iron and Powdered Metals. *Ind. Eng. Chem., News Ed., 18,* 291 (1940). Many applications for pure Fe powder have been established; it is the intention to introduce a variety of plastic metals besides Fe powder for the purpose of facilitating compressing and sintering to form industrial articles.

(3917) Powdered Metal Produces Steel Parts of High Quality. *Machinery (N.Y.), 46,* No. 12, 128-9 (1940). The sintering of "Sinterloy" is conducted in a controlled atmosphere to prevent oxidation and decarburization.

(3918) Sintering Iron Powder. *Metals & Alloys, 11,* No. 5, MA 268 (1940). Composite of abstracts, referring to papers by F. C. Kelley on effect of time, temperature and pressure on the density of sintered metal powders, and by W. Eilender and R. Schwalbe on effect of the same processing variables on the tensile properties of sintered iron.

(3919) Porous Anti-Friction Cast Iron Made from Powder. M. Yu. Bal'shin and N. G. Korolenko, *Metallurgia, 22,* No. 128, 59-61 (1940). Grinding of cast-iron, preliminary annealing and decarburizing, mixing with ferrite iron powder, pressing, sintering; results and applications for wear resistant parts, bearings.

(3920) Investigation of Old German Iron Parts. K. Daeves, *Rundschau deut. Technik, 20,* No. 26, 1-2 (1940). A description is given of a sintering and forging procedure used by the Arabs in the ninth century in producing iron and steel objects.

(3921) A Modern Bearing Alloy Made by Powder Metallurgy. M. Köhler, *Demag. Nachr.,* 14, 29-35; also *Chem. Zentr., 112,* Pt. II, 2994 (1940). Bearing alloy "Pressko" made from sintered Fe and varying amounts of C, consists of ferrite, pearlite and cementite; it is an excellent substitute for bronze and red brass. Material may vary in degree of porosity, including virtually dense structure.

(3922) Durex Iron Finds Many Applications. *Machinery (N.Y.), 48,* No. 4, 158-9 (1941). Compositions of iron powders and graphite for structural parts, bearings, etc. are described.

(3923) Parts Made from Steel Turnings by Compressing and Sintering. *Steel, 108,* No. 21, 76-78, 94 (1941). Starting materials, such as cast iron and steel chips, finished products, and presses are illustrated and discussed.

(3924) Iron and Steel. E. C. Bain, *Mining & Metallurgy, 22,* No. 410, 93-7 (1941). General review of ferrous progress; includes reference to iron and steel powder metallurgy.

(3925) Hot-Pressing of Iron Powders. P. Schwarzkof, and C. G. Goetzel, *Iron Age, 148,* No. 10, 37-44 (1941). Apparatus and technique; pressing temperature; pressure-temperature relationship; hot pressing cycle; subsequent annealing.

(3926) Sintered Parts. *Automobile Engr., 32,* No. 425, 266-8 (1942). A reference to a paper by W. D. Jones, before the Manchester Assoc. of Engineers with regard to steel components, effects of graphite, temperature effects, pressing time.

(3927) Metal Powders. *Iron Age, 149,* No. 8, 49-53 (1942). A pictorial survey of the production of iron powder and products at Moraine Products Division of General Motors.

(3928) R. Durrer, *Die Metallurgie des Eisens.* Verlag Chemie, Berlin, 1942. Reference is made on p. 417 to the fact that sponge iron powder from Sweden was, for a long time, the starting material for iron compacts in the United States.

(3929) Hot-Pressing of Iron Powder. C. G. Goetzel, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 36, pp. 395-407. Hot pressing cycle and subsequent annealing applied to electrolytic, hydrogen-reduced, and Swedish iron powder are investigated.

(3930) Sintered, Forged and Rolled Iron Powders. C. G. Goetzel, *Iron Age, 150,* No. 14, 82-92 (1942). Soft iron powder compacts tested for mechanical properties; raw material and procedure described; sintered iron compared with hot-forged and cold-rolled iron.

(3931) Manufacture of Articles from Powdered Metals. W. D. Jones, *Machinery (London), 59,* No. 1526, 418-19 (1942). Iron parts by cold and hot pressing are discussed.

(3932) Hot-Forging of Iron Powder Briquettes. R. P. Koehring, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 27, pp. 304-309. Tensile test bars prepared and tested for physical properties.

(3933) Sintering of Iron Powder. J. Libsch, R. Volterra, and J. Wulff, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 35, pp. 379-394; **also**

Metal Progress, 41, No. 4, 528-30, 540, 550 (1942). Pressing; thermal sintering, recrystallization and grain growth; effect of particle size; post working.

(3934) Iron Powder Substitute for Bronze. A. F. Macconechie, *Steel, 110,* No. 11, 98, 100, 117 (1942). Discussion of powdered iron compacts. Iron ring from steel scrap by hot coining described.

(3935) Sintered Iron for Bearings and Drives in Machine Tool Construction. W. Reuthe, *Maschinenbau, Der Betrieb, 21,* 161-3 (1942); *Chem. Zentr., 113,* Pt. II, 1171-2 (1942). Experiments with various grades of sintered Fe containing 0.03 to 0.3% C, 0 to 4.2% Pb and some amounts of Mn, Si, P and S, and having Brinell hardness of 20-50. Materials of high and low density developed.

(3936) Sliding Bearing of Powdered Metal. E. Rohde, *Z. Ver. deut. Ing., 94,* No. 85, 834-36 (1942); *Chem. Zentr. , 113,* Pt. I, 1182 (1942). High-strength iron-base powdered metals, containing 2-5% lead, form a notable substitute material for brass and bronze. The possibility of making the properties even more favorable by hard surfacing through carburizing or chromizing is indicated.

(3937) Effect of Pressure on the Properties of Compacts. C. W. Balke, *Symposium on Powder Metallurgy,* ASTM, Philadelphia, 1943, pp. 11-24. Properties of iron, carbon steels and alloy steels, *e.g.,* of the manganese-molybdenum type, are greatly enhanced by highest purity and freedom from gases of the iron powder (electrolytic), and by very high molding pressures and compact densities.

(3938) Iron Powder. C. V. Firth, *Univ. Minnesota Mines Expt. Sta., Information Circ. No. 3,* 1943. Production of iron powder; products by compression at 10-40 tsi and heating in oxygen-free atmosphere, followed by hot- or cold-compression (coining).

(3939) Elongation and Tensile Strength of Sintered Iron Piston Rings. O. Hummel, H.F.C. Docum. No. 12387 (1943). Rings were H reduced to 0.6% C but were not satisfactory in service. Ferrous powders containing up to 0.5% Cr, Mo or V were used for improving the tensile properties, but no results were obtained.

(3940) Powder Metallurgy. F. V. Lenel, *Automobile Eng., 33,* No. 441, 415-18 (1943). Discussion of uses of sintered iron and sintered steel.

(3941) Iron Powder Metallurgy. F. V. Lenel, *Engineering, 156,* No. 4057, 305 (1943). The physical properties of parts made from iron powder are discussed.

(3942) Powdered Metal Process for Molding Parts. H. W. Perry, *Aircraft Engr., 15,* No. 176, 305-306 (1943). Steps in production of powdered ferrous products are outlined, principal advantages stated, applications.

(3943) Sintered Iron of Improved Strength. F. Eisenkolb, *Metallwirtschaft, 23,* No. 40-43, 373-377 (1944). A correlation between hardness and tensile strength with porosity as a parameter is established for sintered iron and steel on the basis of comprehensive experimental data.

(3944) Piston Rings. J. A. Judd, *Automobile Engr., 34,* No. 453, 379-80 (1944). Application of powder metallurgy technique by British Piston Ring Co., Ltd., to manufacture of piston rings.

(3945) Physical Properties of Parts Made from Iron Powder. F. V. Lenel, *Practical Engr., 9,* 172-73 (1944). It is shown that the mechanical properties of sintered metals are significantly affected by the degree of density attained in the body.

(3946) Comparative Properties of 0.55 Carbon Steel Bars Formed by Conventional and Powder Metallurgy Methods. A. Squire, *Watertown Arsenal Lab. Rept. WAL. 671/18,* July 20, 1944, 8 pp.; U. S. Dept. Comm. PB. 4419/1944. Data presented in tabular form. Steel powder compacts exhibited an unusual combination of strength and ductility in every state of heat treatment.

(3947) Iron-Graphite Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept. WAL 671/14,* Aug. 10, 1944, 23 pp.; U. S. Dept. Comm. PB. 4420/1944. Strength of compacts of the composition 99% Fe-1% graphite, formed by using graphite of 4 different average particle sizes, were increased as the particle size was reduced. Other values given in tables and graphs.

(3948) Evaluation and Correlation of the Quality Characteristics of Powdered Iron Compacts. A. Squire, *Watertown Arsenal Lab. Rept. WAL 671/12*, June 17, 1944, 36 pp.; U.S. Dept. Comm. PB. 4416/1944. Values of the quality characteristics of Fe powder compacts were found to be dependent upon the material from which the compacts are formed and the processing operations which they subsequently receive. Graphs and tables; photographs.

(3949) Density as a Criterion of the Mechanical Properties of Fe Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept. WAL 671/16*, Oct. 31, 1944, 28 pp.; U.S. Dept. Comm. PB. 4417/1944. Mechanical properties of compacts formed from 6 types of Fe powder were found to be dependent upon density of the compacts.

(3950) Evaluation and Correlation of the Properties of Heat-Treated Iron-Graphite Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept. WAL 671/17*, Dec. 1944, 8 pp.; U.S. Dept. Comm. PB. 4418/1944. Physical property correlation determined for unalloyed iron compacts were found to be good also for heat-treated steel compacts formed from commercial mixture of Fe and graphite.

(3951) Powder Metallurgy Research Reported. *Iron Age, 155*, No. 8, 72-77 (1945). Abstracts of 2 papers on powder metallurgy published by A.I.M.E.: "Hot Pressing of Electrolytic Iron Powders" by O. Henry and J. Cordiano; and "Problems Involved in Pressing of Compacts Having Complicated Shapes" by C. G. Goetzel.

(3952) Effect of Method of Iron Powder Production on the Properties of Sintered Compacts. W. Dawihl, and U. Schmidt, *Stahl u. Eisen, 65*, 9-14 (1945); *C. A., 41*, 2679 (1947). Iron powders included in this investigation were produced by six different methods.

(3953) Iron Powder Parts. C. Ernst, *Iron Age, 155*, No. 15, 96 (1945). Query and answer by editor on stake pockets for motor trucks.

(3954) The Effect of Sintering Conditions on Mechanical Property-Density Relationship of Iron Powder Compacts. E. M. Rubino, and A. Squire, U.S. Dept. Comm. PB. 4072/1945, 10 pp.; *Bibl. Scient. & Ind. Rept., 1*, No. 8, 304 (1945). Considerable experimental data are tabulated and analyzed.

(3955) Cemented Steels Are Perfected. *Business Week*, No. 873, 50-54 (1946). Involves infiltration of molten copper into compact formed by pressing iron particles; uses low-cost materials; provides parts of high density.

(3956) Chevrolet Makes Parts Directly from Steel Chips. *Machinery (N.Y.), 53*, No. 3, 184-187 (1946). Successive steps in the production of bearing lock sleeves.

(3957) Powder Metallurgy of Iron. *Materials & Methods, 23*, No. 1, 224, 226 (1946). A correlated abstract covers papers by C. G. Goetzel, and O. H. Henry and J. J. Cordiano given in *Trans. Am. Inst. Mining Met. Engrs., 166*, pp. 506-519 and 520-532 (1946) and an article in *Am. Machinist, 87*, No. 13, 83-86, June 24, 1943.

(3958) Maximum C in Gas Carburizing. G. H. Boss, *Metal Progress, 50*, No. 4, pp. 657-658 (1946). Test results and observations relating to C absorption in powdered iron compacts sintered in carburizing medium are given.

(3959) Manufacture of Gun Components from Iron Powder. Deutsche Edelstahlwerke and Metallwerk Plansee, F.D. Rept. No. 1722/46 (1946). A complete account, dated 1944, of the preparation of the powder, the press tools, and the sintering schedule, with detailed drawings of the press tools.

(3960) Steel Fabrication: General Review of German Metallurgical Practices. J. H. Frye, *Metal Progress, 49*, No. 1, 76-86 (1946). Powder metallurgy discussed as practiced during war years in Germany. Especially iron rotating bands for projectiles and other products mentioned made by different firms.

(3961) Use of Graphite in Iron Powder Compacts. E. S. Glauch, *Proc. Second Ann. Spring Meeting of Metal Powder Assoc.*, New York, June 13, 1946, pp. 2-12. A discussion is presented of constant conditions, *e.g.*, iron powder, graphite addition, compacting pressure, sintering temperature and atmosphere, cooling rate, mixing technique; and of variable conditions, *e.g.*, iron powders, test specimens, sintering atmosphere and sintering container.

(3962) Pressing Complicated Shapes from Iron Powder. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 166*, 506-519 (1946). The production of sintered iron parts is described.

(3963) Hot-Pressing of Iron Powders, O. H. Henry, and J. J. Cordiano, *Trans. Am. Inst. Mining Met. Engrs., 166,* 520-32 (1946). Purpose of investigation; apparatus; material and procedure; discussion of results with microphotographs and curves. Submitted as part of thesis.

(3964) Production of Aircraft Piston Rings by Powder Metallurgy. J. A. Judd, *Machinery (London), 69,* No. 1763, 109-112 (1946). Account of development of process by British Piston Ring Co., including press design and operation and details of sintering and pressing of rings from steel powder mixtures.

(3965) Iron Powder Metallurgy. A. J. Langhammer, *Proc. Second Ann. Spring Meeting, Metal Powder Assoc.,* New York, June 13, 1946, p. 53. Introduction and discussion to session on Fe powder metals.

(3966) Sintered Iron and Steel Components. C. J. Leadbeater, B.I.O.S. Final Rept. No. 595, 1946, 61 pp.; *Met. Powd. Rept., 1,* No. 4, 53 (1946). Sintered steel parts were manufactured from a mixture of D.P.G. powder and cast iron powder containing 3-3½% C., with additions of 0.5-1% graphite and 0.03% lubricant oil. This mixture was pressed at 32-38 tsi, sintered at 900° C. (1650° F.) for one hour, repressed at 32-38 tsi, and resintered at 1250° C. (2280° F.) for 2 hours. The compacts produced in this way had a density of 7.1-7.3, tensile strengths of 32-38 tsi, 5-7% elongation, and a Brinell hardness of 150. An interesting press, used for making feeder components, is also described.

(3967) Sintered Iron and Steel Components. C. J. Leadbeater, U. S. Dept. Comm. PB. 46386/1946, 61 pp.; *Bibl. Scient. & Ind. Rept., 3,* No. 13, 955 (1946). Report contains sections on sintered iron driving bands, bullet cores, sintered steel. *Cf:* B.I.O.S. Final Rept. 595 (1946).

(3968) Some Relationships between Properties of Iron Powders and Properties of Parts Made from Them. F. V. Lenel, *Proc. Second Ann. Spring Meeting of Metal Powder Assoc.,* New York, June 13, 1946, pp. 65-72. The predominant role played by the green or compact density is described. The diffusion of graphite into iron powders in iron-graphite mixes is also discussed, and hardening of sintered steel is reviewed. Tensile properties of sintered steel from different iron powders are reported.

(3969) Carbusintering of Iron Powders. A. S. Margolies, *Iron Age, 157,* No. 9, 60-63 (1946). Iron powder is compacted at various pressures and then carbu-sintered, *i.e.,* carburized and sintered simultaneously. Microstructure and physical properties are reported.

(3970) Powder Metallurgy of Iron. G. H. S. Price, *Metal Treatment, 12,* 275-286 (1946). Nature of powder; particle size and shape. Effect of pressure in relation to density and cohesion of compacts and the relation of conductivity to pressure. Mechanical and physical properties. References.

(3971) Parts from Powders - Manufacture of Ferrous Metal Powder Parts. P. Schwarzkopf, and C. G. Goetzel, *Metal Progress, 49,* No. 3, 539-547 (1946). Pictorial Story photographed by F. M. Demarest at plant of American Electro Metal Corp. in Yonkers, N.Y.

(3972) Iron Powders and Products. A. Squire, U. S. Dept. Comm. PB. 4066/1944, 36 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 8, 304 (1946). Close control of O content and particle porosity needed to assure uniformity of the product. Tensile properties of compacts pressed from electrolytically produced powders were superior to compacts produced by other methods. Addition of small percentage of alloying elements to iron powder is beneficial.

(3973) Influence of the Processing Conditions upon Density - Mechanical Property Relationship of Iron Powder Compacts. A. Squire, U. S. Dept. Comm. PB. 4073/1945, 13 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 8, 304 (1946). A direct relation between the density and the mechanical properties was found to exist irrespective of the other powder metallurgy variables.

(3974) Comparative Properties of 0.55 Carbon Steel Bars Formed By Conventional and Powder Metallurgy Methods. A. Squire, U. S. Dept. Comm. PB. 4419/1944, 8 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 8, 591 (1946). The steel powder compacts exhibited an unusual combination of strength and ductility. The numerical values of the tensile strength were lower than those of wrought material.

(3975) Densities of Iron Powder Compacts. R. Steinitz, *Powd. Met. Bull., 1,* No. 5, 70-71 (1946). Magnetic properties of parts made from iron powders depend on the density of the finished compacts. A large range of densities can be produced easily by using different iron powders and pressures.

(3976) A Study of the Physical Properties and Microstructure of Sintered Steel. G. Stern, *Trans. Am. Inst. Mining Met. Engrs., 166,* 556-573 (1946). Tests made on electrolytic iron plus graphite and on reduced iron plus graphite. Raw materials and experimental procedure described. Results are plotted in graphs showing properties *vs.* C content. Micropictures and tables show structure and physical properties *vs.* treatment, respectively.

(3977) Development of Carbon Sinter Steels for Weapon Parts and Other Uses. H. Wiemer, U.S. Dept. Comm., PB. 6794, 1946, 3 pp. Gives result of research on the chemical, physical and mechanical properties and the structure of sinter material from iron and carbon in their relationship to sinter temperature, sinter time and atmosphere; the properties of iron powder and with various carbon additions. Results summarized in text and tables.

(3978) Revue of Work of Kaiser Wilhelm Institut on Powder Metallurgy. H. Wiemer, U.S. Dept. Comm. PB. 14760, 1946, 11 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 19, 1108 (1946). Sintering experiments with Fe powders containing C are reported.

(3979) Carbon-Sinter Steels for Armament Parts. H. Wiemer, U.S. Dept. Comm. PB. 20095, 1946, 4 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 13, 976 (1946). Experiments carried out at Pulvermetallurgisches Laboratorium am Kaiser Wilhelm Institut für Eisenforschung. Four iron-base materials were tested and the results are given in a table.

(3980) Development of Sintered Iron Components, Especially Fuse Parts. A.G. für Bergbau u. Hüttenbedarf, F.D. Rept. No. 1139/47 (1947). In a general description, dated 1946, of the manufacturing process it is stated that oxide-reduced iron powders required higher compacting pressures than Hametag powder.

(3981) Properties of Certain Iron Powder Compacts. J. P. Burr, and W. Clarke, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Report No. 38, London, 1947, pp. 113-6; *Met. Powd. Rept., 1,* No. 12, 178 (1947). Compacts requiring high ejection pressure are sintered under the following conditions: (*1*) sintered 1 hr. at 1100° C. (2000° F.) in H; (*2*) second set coined at 40 tsi; (*3*) third set sintered, coined, and resintered for 1 hr. in H at 1100° C. (2000° F.).

(3982) Manufacture and Use of Iron Powder in Germany. W. G. Cass, *Ind. Diamond Rev., 7,* No. 78, 152-3 (1947). A review of B.I.O.S. Final Reports No. 860, "Iron Powder, Note on German Production Methods at Düsseldorfer Eisenhüttengesellschaft, and Deutsche Eisenwerke" by J. C. Richards; and No. 908, "Manufacture of Products from Metal Powders" by A. G. Haffenden.

(3983) Pressing, Sintering, Heat Treatment and Properties of Iron-Graphite Powder Mixtures. R. Chadwick, and E. R. Broadfield, *Symposium on Powder Metallurgy.* The Iron & Steel Inst. Spec. Rept. No. 38, London, 1947, pp. 123-141; *Met. Powd. Rept., 1,* No. 12, 179 (1947). Investigation into preparation of sintered steel from mixture of: electrolytic iron powder, Swedish sponge iron powder, and German powder made by Degussa process.

(3984) Development of Sintered Bearings. F. Eisenkolb, *Arch. Metallkunde, 1,* No. 7/8, 345-352 (1947). Review of German literature on performance of sintered dense iron bearings.

(3985) Mechanism of Pressing of Iron Powder. F. Eisenkolb, *Stahl u. Eisen, 66/67,* 78-82 (1947). Research is reported on the compaction of powdered iron from different origins. The influence of particle size and of aging and addition of graphite and artificial resin to the iron powders is investigated.

(3986) Iron Carbon Alloys by Powder Metallurgy. J. A. Judd, *Symposium on Powder Metallurgy.* The Iron & Steel Inst. Spec. Rept. No. 38, London, 1947, pp. 117-122; *Met. Powd. Rept., 1,* No. 12, 178 (1947). With existing equipment where compacting pressures are restricted to 50 tsi and sintering temperatures to 1150° C. (2100° F.), it is difficult to produce sintered steel with a density higher than 90% of the theoretical density. Author discusses three techniques available for producing high-density iron-carbon alloys.

(3987) Formation and Transformation Studies of Iron-Carbon Powder Alloys. J. F. Kahles, *Trans. Am. Soc. Metals, 38,* 618-658 (1947). Results of study of reactions show that very pure steels may be prepared by pack carburizing compressed carbonyl-iron powder, and that austenite transformation characteristics of these powder products do not differ from steel made from the liquid state.

(3988) Sintered Iron and Steel for Structural Parts. R. Kieffer, F. Benesovsky, and H. Bartels, *Industrie u. Technik, 2,* 64-66, 88-92 (1947); *Powd. Met. Bull., 2,* No. 3, 54-69 (1947). Discussion of sintered iron and steel as construction material; utilization of porosity and plasticity; sintered parts produced at lower cost; production of sintered steel; technological characteristics.

(3989) Bearings, Bushings and Allied Products. A. J. Langhammer, *Proc. Third Ann. Spring Meeting, Metal Powd. Assoc.,* New York, May 27, 1947, pp. 32-4. Application of bearings and machine parts made by powder metallurgy; greatest opportunities seen in machine parts from iron powders.

(3990) Iron Powders and Sintered Components. C. J. Leadbeater, and V. G. Ford, B.I.O.S. Final Rept. No. 1223, 106 pp. (1947); *Met. Powd. Rept., 2,* No. 1, 3-4 (1947). Report of methods used in various German factories for the production of raw materials and the fabrication of components.

(3991) Some Properties of Engineering Iron Powders. C. J. Leadbeater, L. Northcott, and F. Hargreaves, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Report No. 38, London, 1947, pp. 15-36; *Metal Powd. Rept., 1,* No. 6, 91-94 (1947). Pressed and sintered compacts of 28 commercial powders were tested for the full range of mechanical properties; a large number of simple correlation coefficients were described from the results by statistical analysis.

(3992) Powdered Iron Products Having Widely Varying Properties. Ya. M. Lipkes, and L. A. Faikina, *Stal, 7,* 149-153 (1947); *C. A., 41,* No. 18, 5833 (1947). Powder contained 97-98% Fe and small quantities of C. Properties were only slightly affected by increasing fineness of the powder; best sintering temperature was found at 1200° C. (2200° F.).

(3993) Iron-Graphite Powder Compacts. A. Squire, *Trans. Am. Inst. Mining Met. Engrs., 171,* 473-484 (1947). Paper is based on *Watertown Arsenal Laboratory Rept. WAL 671/14,* of Aug. 10, 1944. (U.S. Dept. Comm. PB. 4420/1944, 23 pp.) Investigation of processing variables and their effect on the properties.

(3994) Density Relationship of Iron Powder Compacts. A. Squire, *Trans. Am. Inst. Mining Met. Engrs., 171,* 485-505 (1947). Paper is based on *Watertown Arsenal Laboratory Report WAL 671/16,* of October 31, 1944 (U. S. Dept. Comm. PB. 4417/1944, 28 pp.). Test methods of materials, relationship between density and mechanical properties of iron powder compacts, and influence of dimensions on the density were studied; results given in form of graphs.

(3995) Sintered Iron Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3964/47 (1947). Effect of pressing and sintering conditions on properties of sintered iron compacts reported in 1944.

(3996) Plastic Mold Cavities of Powdered Metal. E. R. Walter, *Materials & Methods, 26,* No. 1, 125 (1947). Condensed from paper given before Soc. Plastics Ind., May 9, 1947. Process used in manufacturing of powdered metal cavities for plastic molds is similar to that used in production of powdered metal gears. Electrolytic iron powder is pressed, sintered, coined, carburized and hardened, then finished.

(3997) Technology of Sintered Iron. H. Wiemer, *Arch. Metallkunde, 1,* No. 7/8, 323-327 (1947). Laboratory work done during war at Kaiser Wilhelm Institut for iron research is discussed with table of physical properties of sintered iron and steel under varying conditions.

(3998) Influence of Small Quantities of Normal Steel Constituents on Properties of Sintered Soft Iron. H. Wiemer, F. D. Rept. No. 4046/47 (1947). The effects of O, S, P, N on sintered soft Fe were studied at the Kaiser Wilhelm Institut für Eisenforschung.

(3999) Effects of Small Contents of Elements Present in Steel on Properties of Sintered Soft Iron. H. Wiemer, U. S. Dept. Comm. PB. 14761, 2 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 19, 1108 (1947); *Powd. Met. Bull., 1,* No. 6, 92 (1947). Effect of

oxygen, sulfur, phosphorus, nitrogen, with special attention to the effect of contaminations contained in the sintering atmosphere.

(4000) Compacting of Iron Powders. *Iron Age, 162,* No. 22, 96-98 (1948). A summary of an article by F. Eisenkolb in *Stahl u. Eisen, 66/67,* 78-82 (1947).

(4001) Powder Metallurgy of Iron. H. Bernstorff, and H. Silbereisen, *Arch. Metallkunde, 2,* No. 7/8, 295-300 (1948). Special emphasis on sintered steel and its application; development of powder metallurgy; preparation of Fe powders; characteristics of sintered Fe; manufacture of sintered steel; mechanical properties and post-treatments; use of powdered parts in bearings, magnets, etc.; comparison between machined and sintered parts; practical considerations.

(4002) Notes on Steel and Alloy Steels. H. W. Greenwood, *Iron and Steel, 21,* No. 5, 183-4 (1948). German practice producing steel parts from iron powder by atomizing and from Swedish sponge iron. The oxide of iron does not influence the decarburization. Use of hydrides is also discussed.

(4003) T. Hövel, *Sintereisen.* Vieweg, Braunschweig, 1948. A report of the development of powder metallurgy in Germany during the war. Discussion of the production of complicated parts for projectiles from sintered iron.

(4004) Evaluation of Molding, Coining and Sintering Properties of Iron Powders. J. F. Kuzmick, *Trans. Am. Inst. Mining Met. Engrs., 175,* 813-833 (1948). Methods for the evaluation of molding, coining, and sintering properties of iron powder are presented. The application of these methods to Swedish iron powder is shown and some mechanical properties are presented by way of illustrations.

(4005) Structural Parts of Iron Produced in USA. F. V. Lenel, *Oesterr. Chem. Ztg., 49,* No. 10/11, 190 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 64. Author refers to the standard designations by the American Society for Testing Materials, as related to the iron powder parts production, and a classification of materials, types, and properties as related to uses. Also given is a broad review on the subject.

(4006) Physical Properties of Sintered Compacts from Reduced Iron Powder Plus Graphite and Copper. G. Stern, *Met. Powd. Rept., 3,* No. 1, 3 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 190 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 57. By adding 2 or 5% Cu and 0.85% graphite to oxide-reduced Fe powder it was found that, after heat treatment, the tensile strength was comparable to equivalent cast carbon steel, and higher than compacts not containing Cu, but that the elongation and reduction-in-area values were decreased. No pressing lubricant was added, but die walls were coated with Sterotex in acetone.

(4007) State of Processing Technique in the Powder Metallurgy of Iron. H. Timmerbeil, and O. H. Hummel, *Arch. Metallkunde, 2,* No. 1/2, 30-35 (1948). Production of technical iron powder, pressing and sintering processes, and properties of the compacts are described.

(4008) Sintered Iron and Carbon Articles. H. Wiemer, and W. A. Fischer, *Arch. Eisenhüttenw., 19,* 125-35 (1948). A sintered mixture of Fe and C in vacuo produces ferritic-graphitic and pearlitic structures. The mechanical strength depends on the C content, sintering time and temperature; the sintering atmosphere has no influence.

(4009) Sintered Iron and Sintered Steel. F. Benesovsky, *Einführung in die Pulvermetallurgie.* Technische Hochschule Graz, 1949, pp. 84-101. Starting powders, pressing, sintering, and subsequent treatments. Properties of sintered parts.

(4010) Why Use Sintered Iron? L. A. Richter, *Oesterr. Maschinenmarkt u. Elektrowirt., 4,* 5-6 (1949). The advantages of sintered iron are discussed.

(4011) Physical Properties of Reduced Iron Powders. G. Stern, *Iron Age, 163,* No. 12, 81-85 (1949). The paper given at the International Powder Metallurgy Conference at Graz in 1948 is presented.

(4012) Properties of Carburized Sintered Steel. G. Will, *Stahl u. Eisen, 69,* 630-35 (1949). An attempt to increase the strength of iron parts by either gas carburizing or addition of graphite or cast iron powder. Good mechanical

properties were obtained with a mixture of iron powder with Acheson graphite, and with cast iron powder.

(4013) Sintered Carbon, Sintered Iron and Graphite as Materials for Machine Construction. H. Winkelmann, *Werkstatt-Betrieb, 82,* 239-40 (1949). A review of iron and steel powder metallurgy is given with special reference to wear parts and bearings.

B. Alloy and stainless steels

(4014) Note on Stainless Steel from Powdered Metals. E. F. Cone, *Iron Age, 133,* No. 25, 27 (1934). Process for making stainless steel by intimately admixing 74% Fe, 8% Ni, 18% Cr powder, pressing at 20,000 psi, and heating at 1200° C. (2190° F.) in a nonoxidizing atmosphere.

(4015) Stainless Steel Powder. J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, Chapter 11, pp. 137-144 (1942). Powder produced by alloy disintegration was pressed into compacts; corrodibility and applications are discussed.

(4016) Alloy Steel from Powders. J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 28, pp. 310-313. Series of tests conducted on forged, cold pressed and sintered pieces, from alloy powders pulverized from steel scrap, of various alloy steel analyses.

(4017) Hot-Pressed Alloy Steels May Be Available in 1945. G. J. Comstock, *Steel, 116,* No. 1, 382 (1945). Cheap method of producing alloy steel powders for this purpose now being investigated.

(4018) Stainless Steel Parts by Powder Metallurgy. *Chem. Eng. News, 24,* 1842 (1946). The production of machine parts from stainless steel is described.

(4019) Set Prices for New Powders and Flake of Stainless Steel. *Iron Age, 158,* No. 12, 138-39 (1946). Stainless steel parts for the machine industry are described.

(4020) Engineering News at a Glance. *Steel, 118,* No. 25, 114 (1946). Stainless steel parts made by powder metallurgy are now being offered on a mass production scale by Micro Metallic Co.

(4021) Stainless Steel. J. D. Dale, *Proc. Third Ann. Spring Meeting,* Metal Powder Assoc. New York, May 27, 1947, 4-13. The preparation and physical properties of low carbon type 18-8 stainless steel are reported.

(4022) Metallurgy of Powdered Metals. L. Delisle, and W. V. Knopp, *Rev. met., 44,* 245-255 (1947). Fe, Ni powder, 80% FeMn, 20% FeSi were mixed and ground to pass 44-μ sieve, then compressed to produce a 0.40% C alloy of Fe-C, 0.40% C - 3.5% Ni steel and 0.75% Mn, 0.2% Si, 3.5% Ni alloy. The compacts were sintered for 3 hrs. in closed container, cooled, reheated to 875° C. (1610° F.), then oil quenched and drawn. Physical properties were determined. The sintering effect shows a break at 1250° C. (2280° F.).

(4023) Increase in Life of a Smoke Exhaust Fan. A. F. Tagin, *Ind. Power (U.S.S.R.), 4,* No. 2, 12 (1947). Application of powder metallurgy containing 18% Cr, 10% C, 15% Mn, 2% Si, 55% Fe to the blades to prevent corrosion.

(4024) Nickel-Steels by Powder Metallurgy. L. Delisle, and W. V. Knopp, *Trans. Am. Inst. Mining Met. Engrs., 175,* 791-812 (1948). Diffusion of nickel takes place in solid state to an extent sufficient to change mechanical properties of steel. Alloy powders offer a field of investigation toward the production of homogeneous nickel steel.

(4025) Investigation of Sintered Manganese and Chromium-Manganese Steels. F. Benesovsky, and R. Kieffer, *Met. Powd. Rept., 3,* No. 1, 3; *Oesterr. Chem. Ztg., 49,* No. 10/11, 189 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 27. Heat-treatable Mn steels with 2-16% Mn and 0.2-1.6% C were made from Hametag powder and ferro-manganese by pressing at 25-50 tsi and sintering in H at 1200° C. (2190° F.) Low alloys with 1-5% Mn, 1-5% Cr, 0.5-1.5% C were

prepared, but difficulties arose with high Mn-Cr alloys. Cu impregnation was tried with interesting results.

(4026) Finished Stainless Powder Parts. *Steel, 125,* No. 26, 55-6 (1949). Mass production of finished machine parts from stainless steel powder, in wide range of sizes and shapes, reported by Amplex Division of Chrysler Corp., original metal from which powder is produced is sheet stock; after chemical treatment, metal resembles flexible strip of rubber; manufacture of parts from powder involves normal operations of mixing, briquetting, heat treating and sizing.

(4027) Alloy Steels. H. W. Greenwood, *Iron & Steel, 22,* No. 1, 9-10 (1949). Powder metallurgy offers advantages in production of small parts by overcoming difficulties of machining and casting; most interesting alloy steels for powder metallurgists are discussed; results of experimental work with alloys are reported. The importance is stressed of the principle of compaction by combined use of pressure and presence of small percentage of liquid phase, *e.g.*, as obtained by hot-pressing.

C. Iron alloys and composites (with nickel, cobalt, copper, lead, light metals, oxides, etc.)

(4028) Bearing Metals and Stamping Alloys. W. Guertler, *Metallurgie, 7,* No. 9, 264-8 (1910). A powdered mixture of Fe and Pb was heated and stamped into shapes.

(4029) Resistance of Iron-Aluminum Alloys to Oxidation at High Temperatures. N. A. Ziegler, *Trans. Am. Inst. Mining Met. Engrs., 100,* 267-71 (1932). Tables for the oxidation resistance are given.

(4030) Alloys of Silver and Iron. C. G. Fink, and V. S. de Marchi, *Trans. Electrochem. Soc., 74,* 271-85 (1938). Maximum amount of Ag alloyed with Fe was between 0.5-1%. Additional evidence that Ag alloys with Fe is shown by the fact that ferrite grains of a 50:50 alloy are stained. This is similar to the observation made on Cu-Fe alloys.

(4031) Intermetallic Compounds by Diffusion of Iron and Aluminum. W. Seith, and C. Ochsenfarth, *Z. Metallkunde, 35,* 242-5 (1943). Specimens of mixtures of pure Fe and Al powders are heated in a reducing atmosphere at 950° C. (1740° F.) and examined microscopically, by x-ray and by hardness measurements.

(4032) Properties of Iron-Copper Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept. WAL 671/8* (1944). Data obtained from investigation on iron-copper powder mixtures and compacts thereof are presented and discussed.

(4033) Nickel-Iron Alloys Produced by Powder Metallurgy. L. Delisle, and A. Finger, *Trans. Am. Inst. Mining Met. Engrs., 166,* 574-587 (1946). Procedure; raw materials; mixing; pressing; sintering; testing; microscopic examination; tensile strength; yield strength; hardness; elongation; microstructure; conclusions.

(4034) Sinteel G. C. Dinsdale, *Metal Treatment, 13,* No. 46, 140-41 (1946). Production technique of infiltrating porous sintered iron with molten copper and use of the resulting material for structural parts are described.

(4035) Cemented Steels – Infiltration Studies with Pure Iron and Copper Powders. C. G. Goetzel, *Powd. Met. Bull., 1,* No. 3, 37-43 (1946). Processing: compacting, infiltration and sintering, subsequent heat treatment; properties given in tables and micropictures; mechanism of cementing.

(4036) Properties of Sintered Iron-Copper Powders. F. C. Kelley, *Iron Age, 158,* No. 7, 57-60 (1946). Effects of variations in sintering temperature, time and Cu content, on physical properties of sintered Cu-Fe are discussed.

(4037) Cemented Steels. E. S. Kopecki, *Iron Age, 157,* No. 18, 50-54 (1946). A new development in powder metallurgy may remove present-day limitations of powder metallurgy of iron and steel. Complicated shapes of high strength and

density can now be produced utilizing low pressures and an infiltration method involving copper.

(4038) Cemented Steels – A New High-Strength Powder Metallurgy Product. F. P. Peters, *Materials & Methods, 23,* No. 4, 987-991 (1946). Production technique involving infiltration of low-melting metal into steel sponge; characteristics of iron-copper base materials with table of physical properties, fields of use, etc.

(4039) Properties of Iron-Copper Powder Compacts. A. Squire, U.S. Dept. Comm. PB. 4060/1946, 49 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 8, 304 (1946). Presentation and discussion of data obtained from investigation made to determine the effect of processing conditions upon physical properties of Fe-Cu powder compacts.

(4040) Cemented Iron Powders. S. Tour, *Iron Age, 158,* No. 6, 98 (1948). Letter to the Editor. Report on steel filings made into compacts and cemented together with copper.

(4041) Pressing, Sintering and Properties of Iron-Copper Mixtures. R. Chadwick, E. R. Broadfield, and S. F. Pugh, *Symposium on Powder Metallurgy.* The Iron & Steel Inst. Spec. Rept. No. 38, London, 1947, 151-157; *Met. Powd. Rept., 1,* No. 12, 180 (1947). Four iron powders and two copper powders were used. Effects of variations in the particle size, pressure, sintering temperature were studied.

(4042) Sintered Iron-Copper Alloys. F. C. Kelley, *Iron Coal Trade Rev., 154,* 1142 (1947). The strength and ductility of Cu-Fe mixtures, pressed and sintered at 1100-1340° C. increase with the temperature of sintering.

(4043) Sintered Iron-Copper Compacts. L. Northcott, and C. J. Leadbeater, *Symposium on Powder Metallurgy.* The Iron & Steel Inst. Spec. Rept. No. 38, London, 1947, pp. 142-150; *Met. Powd. Rept., 1,* No. 12, 179-180 (1947). Compacts made from a series of iron powders and copper powders differing in their method of production and size. Best results obtained with fine Cu-powder and sintering at 1100° C. (2010° F.).

(4044) Bending Test Results on Iron-Base Materials. Studiengesellschaft Hartmetall. F. D. Rept. No. 3950/47 (1947). Bending test results on various Fe-metal oxide and Fe-FeS mixtures were reported in 1944.

(4045) Iron Mixtures. Studiengesellschaft Hartmetall. F. D. Rept. No. 3951/47 (1947). Tests on compacts from iron-iron oxide mixtures, reported in 1944, showed that they were inferior to Fe-MnO_2 and Fe-TiO_2.

(4046) Iron Powder Pressings. Studiengesellschaft Hartmetall. F. D. Rept. No. 3953/47 (1947). In 1944, iron powder pressings were sintered in air to 200-350° C. (390-660° F.) for up to 1 hour to obtain partial oxidation and improved hardness.

(4047) Sintering of Iron-Manganese Oxide Powder. Studiengesellschaft Hartmetall. F. D. Rept. No. 3955/47 (1947). Sintering experiments on iron-manganese oxide powder made by coprecipitation from iron chloride and manganese nitrate with ammonia and hydrogen peroxide were reported in 1944.

(4048) Impregnation of Iron Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3956/47 (1947). Impregnation of sintered iron compacts with water-glass or manganese nitrate was reported in 1944.

(4049) Tips of Iron Mixtures. Studiengesellschaft Hartmetall. F. D. Rept. No. 3958/47 (1947). Tips made of Fe-B-Al-Si were found in 1944 to be useless for cutting purposes, whether made by casting or sintering.

(4050) Iron-Manganese Dioxide Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3961/47 (1947). Properties of sintered Fe-MnO_2 compacts are described in this report of 1944.

(4051) Iron Powder. Studiengesellschaft Hartmetall. F. D. Rept. No. 3962/47 (1947). Effect of iron powder quality on properties of Fe-MnO_2 compacts are described in this report of 1944.

(4052) Sintered Compacts of Nickel-Manganese Dioxide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3965/47 (1947). Properties of sintered Ni-MnO_2 compacts are described in report dated 1944.

(4053) Sintered Iron Compacts. Studiengesellschaft Hartmetall. F.D. Rept. No. 3972/47 (1947). Test results on sintered iron compacts made with additions of Cr_2O_3, FeS, Al_2O_3, Fe_2O_3, TiO_2, MgO, MnS were reported in 1943-45.

(4054) Sintered Iron Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3973/47 (1947). Tests on sintered Fe-MnO-Cr_2O_3 compacts were also reported in 1945.

(4055) Iron-Copper Powder. Charles Hardy, Inc. *Metal Powder News, 8,* No. 2 (1948). Describes an Fe-Cu powder containing 8% Cu as coating; compacts, pressed at 40 tsi and sintered in cracked ammonia, had a tensile strength of 48,000 psi and a Rockwell "B" hardness of 50.

(4056) Sintered Compacts of Iron and Light Metal Powders. R. Müller, K. Nitsche, H. Stürzer, and H. Zahabi, *Met. Powd. Rept., 3,* No. 1, 5; *Oesterr. Chem. Ztg., 49,* No. 10/11, 191 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 34b. Mixtures of Fe-Mg were pressed at 7, 15 and 20 tsi, sintered at 250-750° C. (480-1380° F.) for 3-20 hours in H. Nitride formation was prevented by previous mild heating of powders. Fe-Ca and Fe-Ca-Al compacts were made by pressing at 20-150 tsi, sintering for 3-6 hours at 380-1150° C. (715-2100° C.)

(4057) Precipitation Hardening of Iron-Zinc and Cobalt-Zinc Alloys. J. Schramm and A. Mohrnheim, *Z. Metallkunde, 39,* 71-78 (1948). The constitution of the system iron-zinc was investigated with the aid of specimens prepared by powder metallurgy.

6. NON-FERROUS MATERIALS AND PRODUCTS

(4058) Processing of Pulverized Materials. M. Gutman, and G. Leizerovich, *Trans. Mendeleev Congr., Theor. and Applied Chem., 6th Congr., Kharkov, 1932, 1,* Pt. II, 409-20 (1935). A review of processing of non-ferrous metal powders and of the recent progress in the industry of U.S.S.R.

(4059) Non-ferrous Metals. C. Blazey, *Commonwealth Engr., 24,* No. 2, 63-69 (1936). Applications of nonferrous metals and alloys in powdered form are discussed.

(4060) Production of High-Density Parts by Powder Metallurgy. C. Hardy, and G. D. Cremer, *Mining and Met., 23,* No. 10, 509-511 (1942). Electrolytic copper and aluminum powders were processed into compacts which then were tested.

A. Copper and copper alloys

(4061) Powdered Metals. *Mach. Design, 4,* No. 11, 21 (1932). Machine parts of powdered nonferrous metals, bronze bearings discussed.

(4062) Powder Metallurgy Solves Brass Problem. E. F. Cone, *Iron Age, 134,* No. 17, 37 (1934). Mixing the powders and pressing them into shape; subjecting them to proper temperatures result in a perfect production.

(4063) Copper-Powder for Metallo-Ceramic Applications. B. A. Borok, M. Yu Bal'shin, and N. A. Gavrilov, *Niimash, 3,* 27-33 (in Russian). A review of some modern uses in bearing, electrical and other industries.

(4064) Bearings from Metal Powder — A New Art. E. Fetz, *Metals & Alloys, 8,* No. 9, 257-60 (1937). Cu-Pb bearings produced by mixing and impregnation of sponges; suitable for composite bearings.

(4065) Powder Metallurgy in the Electrical Field. C. Hardy, *Metal Progress, 36,* No. 1, 57-59 (1939). Commutator segments, rotor assemblies from sintered copper described; test results on alloying of sintered copper with various elements and several stage pressing and sintering.

(4066) Lead-Bronze Bearings. Copper Development Association, London, No. 33, 1940, 48 pp. Partly deals with powder metallurgical method of producing copper-lead bearings. Cu powders are mixed with Cu-coated Pb powders, pressed and sintered.

(4067) Structure and Properties of Copper Powder Compacts. C. G. Goetzel, *J. Inst. Metals, 66,* No. 9, 319-329 (1940); *Discussion, 67,* No. 3, 115-6 (1941). The powder metallurgy of copper is illustrated by experimental results.

(4068) Powder Metallurgy of Copper. C.G. Goetzel, *Metals & Alloys, 12,* No. 1, 30-35; No. 2, 154-157 (1940); *Metal Ind. (London), 57,* No. 16, 306-308; 334-336 (1940). Investigation of microstructure and physical properties as a function of the powder characteristics and processing conditions.

(4069) Some Properties of Hot-Pressed and Sintered Copper Powder Compacts. C. G. Goetzel, *Trans. Am. Soc. Metals, 28,* No. 4, 909-932 (1940). The determination of the effect of variations of compacting pressure and temperature, and of annealing and of sintering temperature, respectively. Physical and microscopic tests made.

(4070) Properties of Copper Powder Compacts. C. G. Goetzel, *Can. Metals & Metal Ind., 4,* No. 6, 159-160 (1941). Abstracted from *J. Inst. Metals, 66,* No. 9, 319-329 (1940).

(4071) Structure and Properties of Copper Powder Compacts. C. G. Goetzel, *Heat Treating and Forging, 27,* No. 1, 30-31; No. 2, 80-83 (1941). Reprinted and condensed from *J. Inst. Metals, 66,* No. 9, 319-329 (1940).

(4072) Some Properties of Sintered and Hot-Pressed Copper-Zinc Compacts. C. G. Goetzel, *Trans. Am. Soc. Metals, 30,* No. 1, 86-123 (1942); *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, pp. 352-378. Chap. 34. Raw material processing and testing. Microstructure and physical properties, including volume and weight changes.

(4073) J. Newton and C. L. Wilson, *Metallurgy of Copper.* Wiley, New York, 1942. Includes discussion of copper powder metallurgy on pp. 412-15.

(4074) Coalescence Process for Production of Semi-Fabricated Oxygen-Free Copper. J. Tyssowski, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chap. 30, pp. 317-22. Production of anodes and brittle cathodes; briquetting, purification, coalescence and extrusion.

(4075) Copper Powder Metallurgy. *Chem. Age (London), 51,* No. 1310, 137 (1944). Review of paper by J. J. Cordiano before the Electrochemical Society.

(4076) Brass Powder Metallurgy. *Metal Ind. (London), 64,* No. 17, 265 (1944). A table gives pertinent data on pressing and sintering process of test bars. The compacts are compressed at 50 tsi and sintered in H.

(4077) Copper in Powder Metallurgy. J. J. Cordiano, *Trans. Electrochem. Soc., 85,* 97-106 (1944). Three methods of making copper powder, *i.e.,* by electrolysis, by reduction of oxide, and by atomization. Results have effect on particle size and shape of copper powders; description of production of porous bearings, tungsten-copper electrode tips, and steel-backed copper base bearings; products are used for bearings, motor brushes, grinding wheels, clutch facings, etc. Physical properties of finished parts are given in tables.

(4078) What Brass Powder Parts Offer the Designer. E. H. Kelton, *Machine Design, 16,* 129-132 (1944). Machine parts made of sintered brass powder at considerable savings.

(4079) The Production of Sintered Components by the Pressing Process. K. Marquardt, *Metallwirtschaft, 23,* No. 40/43, 377-379 (1944). Mixtures of Cu-Zn and Cu-Al powders were prepared by cold pressing and sintering and by hot pressing, and the resulting products are compared.

(4080) Copper and Copper Alloys. H. J. Miller, *Metallurgia, 31,* No. 182, 83-87 (1944). General survey of technical progress during 1944. Powder metallurgy practice among others.

(4081) Physical Properties of Brass Powders. *Iron Age, 155,* No. 4, 60-62 (1945). Specimens made from 70-30 and 90-10 brass powder with and without added phosphorus investigated. Experiments made at New Jersey Zinc Co.

(4082) Powder Metal Machine Parts. *Machine Design, 17,* No. 10, 133-36 (1945). Illustrations of recently developed complex parts, mainly from bronze, by several companies and description of advantages of powder metallurgy.

(4083) Powder Metallurgy Production of Machine Parts. *Machinery (London), 67,* 337-343 (1945). Gun parts from sintered bronze, now being made in 22 seconds, formerly required 2 hours to machine after forging.

(4084) The Sintering of Metal Powders—Copper. C. J. Bier, and J. F. O'Keefe, *Trans. Am. Inst. Mining Met. Engrs., 161,* 596-611 (1945). Metallography and properties of sintered copper compacts are presented.

(4085) Copper and Copper-Base Alloys. J. W. Donaldson, *Metal Ind. (London), 66,* No. 18, 281-2 (1945). Review of American investigations during 1944. Preparation of Cu and Cu alloys by powder metallurgy.

(4086) Some Properties of Sintered and Hot Pressed Copper-Tin Powder Compacts. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 161,* 580-595 (1945). Experimental procedure and results – discussion of results: material, weight and volume changes, density, hardness, compressive properties, structure; comparison of sintered versus hot pressed materials. Discussion.

(4087) Copper Base Powder Metallurgy. H. Chase, *Materials & Methods, 24,* No. 6, 1439-44 (1946). Dezincification in sintering was overcome by use of moisture-free controlled atmosphere. This allows increased use of brass powder metal parts. Tests on sintered parts by New Jersey Zinc Co. show interesting properties.

(4088) Copper and Copper-Base Alloys. J. W. Donaldson, *Metal Ind. (London), 69,* No. 8, 157-60; No. 9, 171-2; No. 10, 195-6 (1946). Correlated abstract of American research to end of 1945 covering published data including powder metallurgy of Cu and its alloys.

(4089) Notes on Copper-Base Compacts and Certain Compositions Susceptible to Precipitation-Hardening. F. R. Hensel, E. I. Larsen, and E. F. Swazy, *Trans. Am. Inst. Mining Met. Engrs., 166,* 533-547 (1946). Hot-pressing of Cu-powder and heat-treatable Cu-base compacts are described; effect of precipitation hardening on physical and electrical properties of Cu-base compacts is shown by microscopic examination.

(4090) Silicide-Hardened Copper Compacts for Bearings. F. R. Hensel, E. I. Larsen, and E. F. Swazy, *Trans. Am. Inst. Mining Met. Engrs., 166,* 548-555 (1946). Test materials, preparation of compacts, sintering procedure, heat treatment, microscopic examination, physical properties are described. Discussion.

(4091) Effect of Coining on Precipitation Hardening of Sinteel-P. W. N. Pratt, *Powd. Met. Bull., 1,* No. 3, 43-44 (1946). Sinteel-P is a precipitation-hardening product of American Electro Metal Corp. The beneficial effect is only proved qualitatively, but some hardness data are tabulated. Copper-nickel-tin compacts were pressed at 25 tsi, sintered at 985° C. (1800° F.) for 3 hr. in dissociated ammonia, then quenched in 3% alcohol solution; coining was carried out at 40 tsi; part of the bars were reheated at sintering temperature for 1/2 hr.; all bars were precipitation treated at 415° C. (775° F.) for 12 hr. in dissociated ammonia.

(4092) Powder Metal Bronze. H. L. Wain, *Australian Council Aeronautical Rept.* ACA–25 (June 1946). Influence of important processing variables on properties of sintered bronze.

(4093) Production of Parts from Copper Powder. *Métaux et Machines, 31,* No. 325, 404 (1947). Describes the production of parts from copper, bronze, and Cu-Ni alloys.

(4094) Pressing and Sintering of Copper Powder. M. Cook and S. F. Pugh, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 162-173; *Met. Powd. Rept., 1,* No. 12, 181-2 (1947). Ring compacts pressed at 15 to 65 tsi from size-graded fractions of electrolytic powders and oxide-reduced powders; 0.1% zinc stearate added for reducing friction. Compressibility of powders and relation between strength and ductility investigated; properties and micro-examination of structure.

(4095) Production of Bearing Surfaces. R. Delaplace, *Compt. rend., 225,* No. 22, 1075-77 (1947). A lead cored copper wire 1/16 in. in diameter is sprayed by a wire gun into water, so that 95% pass a 200 mesh; after annealing at 290° C. (550° F.) the powder is pressed at 6 tsi and sintered at 800° C. (1470° F.) in a reducing atmosphere.

(4096) Status of Copper Powder Metallurgy. H. Kalpers, *Arch. Metallkunde, 1,* No. 7/8, 368-371 (1947). Flake-type powder has better molding properties than spherical; irregular shapes favor mechanical interlocking. For the manufacture of oil-less bronze bearings is added 1% stearic-acid or ammonium chloride. Addition of graphite minimizes the shrinkage and causes a uniform density.

(4097) Production of Non-Ferrous Engineering Components by Powder Metallurgy. J. W. Lennox, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 174-184; *Met. Powd. Rept., 1,* No. 12, 182-3 (1947). A fully alloyed 70:30 brass powder is used as raw material. Best results are obtained by cold pressing at 30-36 tsi with 1% stearic acid added; and sintering at 900° C. (1650° F.) in H or cracked ammonia. Discussion includes tin-bronzes and review of commercial production items and practices.

(4098) Powder Metallurgy Bearing Materials. W. H. Tait, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 157-161; *Met. Powd. Rept., 1,* No. 12, 181 (1947). Outline is given of the materials and methods used in Great Britain for obtaining non-porous bearing structures which are difficult or impossible to manufacture by means other than powder metallurgy. Information on the influence of structure on the behavior of Cu-Pb bearings and the influence of the modulus of elasticity on the properties of bearing materials is contained in two appendices.

(4099) Nonferrous Powder Metal Parts. D. C. Bradley, *Product Eng., 19,* No. 10, 107-110 (1948). Photographs of parts pressed mainly of copper and brass, and also some of Ni-Ag are shown and the costs of the production are discussed.

(4100) Sintering of Brass Compacts. H. C. Miller, *Proc. Fourth Ann. Spring Meeting Metal Powd. Assoc.,* Chicago, April 15-16, 1948, pp. 70-75. The sintering should be performed at 850-900° C. (1560-1650° F.). The sintering times may be adjusted to fit production schedules based on physical properties desired, which increase with time. Atmosphere for sintering should be a reducing gas.

(4101) Brass Powder Parts in Toys. *Metal Powder Press, 1,* No. 1, 3 (1949). The parts are illustrated and described.

(4102) Ductility in Brass Powder Parts. *Metal Powder Press, 1,* No. 2, 2 (1949). The latch ferrules are made of 80-20 leaded brass powder which shows an elongation of 10% on test bars – ample for the assembly operation.

(4103) Metal Powder Part in New Fire Extinguisher. *Metal Powder Press, 1,* No. 3, 1 (1949). The pressed brass powder latch helps to make a simple and foolproof valve control mechanism.

(4104) Structural Observations on Copper Lead Sintered Alloys. G. Lichtenberg-Strunk, and H. Wiemer, *Arch. Metallkunde, 3,* No. 4, 141-3 (1949). Three different formations observed in alloys containing 10, 30 and 50% Pb, depending primarily upon sintering temperature; photomicrographs.

B. Nickel, cobalt and their alloys

(4105) Stellite. E. Haynes, *Trans. Am. Electrochem. Soc., 37,* 507-12 (1920). A description of the manufacture of Stellite is given. The constituent metals, cobalt, chromium and tungsten, are fused with carbon, or a mixture of their powdered oxides is simultaneously reduced by C or Al in the electric furnace.

(4106) Laboratory Experiments on High-Temperature Resistance Alloys. C. J. Smithells, S. V. Williams, and J. W. Avery, *J. Inst. Metals, 40,* 269-96 (1928). A number of nickel-chromium type alloys were prepared by pressing the mixed powders and sintering. After the first sintering the metal consists of Cr particles embedded in a Ni matrix, but after repeated working and annealing the Cr goes into solution.

(4107) A New Process for the Commercial Production of Nickel. G. Hamprecht, and L. Schlecht, *Metallwirtschaft, 12,* No. 1. 281-84 (1933). Sintering Ni powder

from decomposed nickel carbonyl gives a pure product. Ni-Mn alloys are made by sintering with MnO_2. Ni-Fe alloys and bi-metals are made from carbonyls. Alloys of Ni and Mo, W, Cu and Ag are also described.

(4108) Nickel Parts. *Mech. Engineering, 56,* 561 (1934). Manufacture of nickel parts by sintering is described.

(4109) On the Preparation of Sintered Cobalt-Nickel Alloys. S. Cassirer-Bánó, and J. A. Hedvall, *Z. Metallkunde, 31,* 12-14 (1939). Alloys made from briquetted mixtures of the oxides and then reduced.

(4110) On the Production of Solid Chromium-Nickel Alloys by Reduction of Chromium-Oxide in the Presence of Nickel. G. Grube, and K. Ratsch, *Z. Elektrochem., 45,* 838-43 (1939). Qualitative tests by admixing carbonyl nickel powder, carbonyl iron powder or cobalt powder, and quantitative tests by admixing nickel and chromium oxide, agitated with a mixture of hydrogen and steam, are described.

(4111) Production and Sintering of Powdered Cobalt. J. N. Greenwood, E. J. T. Lumley, and R. W. K. Honeycombe, *Australasian Inst. Mining & Met., 128,* 221-6 (1942). Raw material (cobalt oxide) is reduced to cobalt metal powder at low temperatures by hydrogen, then is compressed and sintered; shrinkage, hardness, structure discussed.

(4112) Dense Nickel Parts from Metal Powder. C. Hardy, *Metal Progress, 44,* No. 4, 634-5 (1943). Carbonyl-nickel test bars were formed of purest powder available and tested. Izod impact test, tension impact test, static tensile test, were made and density was measured. Material compared favorably with wrought Ni.

(4113) Application of Powder Metallurgy. C. G. Fink, and L. Delisle, *Trans. Electrochem. Soc., 85,* 123-130 (1944). 50:50 Co-Cu components are described; the compacts from electrolytically codeposited alloy powder (*cf.* C. J. Fink and J. L. Hutton, *Trans. Electrochem. Soc., 85,* 119-122) are heated in hydrogen to 1090° C. (1990° F.).

(4114) Experiments with Sintered Nickel-Copper Alloys. I. G. Farbenindustrie, Ludwigshafen. F. D. Rept. No. 181/46 (1946). Analytical details of a 65/35 Ni-Cu sintered specimen were reported in 1941.

(4115) Powder Metallurgy of Nickel. G. H. Price, *Metal Treatment, 13,* No. 47, 208-212 (1946). Critical discussion of 42 references in the literature on Ni powder metallurgy.

(4116) Sintered Cobalt. Studiengesellschaft Hartmetall. F. D. Rept. No. 3781/47 (1947). Metallographic and x-ray tests were conducted on sintered cobalt in 1938.

(4117) Sintering of Cobalt. Studiengesellschaft Hartmetall. F. D. Rept. No. 3934/47 (1947). Effect of tensile forces upon shrinkage in the sintering of cobalt were reported in 1943.

C. Low-melting precious metals and alloys

(4118) Silver as Substitute for Scarce Metals. *Iron Age, 149,* No. 8, 48 (1942). Brief item on Ag in powder metallurgy.

(4119) Silver's Importance. W. C. Hirsch, *Automotive & Aviation Ind., 88,* No. 19, 17-19, 61 (1942). Application of silver in powder metallurgy.

(4120) Industrial Uses of Silver. A. M. Setapen, *Metals & Alloys, 16,* No. 1, 46-51 (1942). Powder metallurgy of silver discussed.

(4121) Certain Characteristics of Silver-Base Powder Metallurgical Products. F. R. Hensel, and E. I. Larsen, *Trans. Am. Inst. Mining Met. Engrs., 161,* 569-579 (1945). Tests on coin and Sterling silver compacts, using alloy powders; also tests on Ag-Ni-Cu and Ag-CdO compacts; results given by tables and diagrams.

(4122) Fabrication of Gold-Beryllium Alloys. H. Hirsch, and J. M. Taub, *MDDC-1333,* Atomic Energy Commission Publ., 1947, 4 pp. (also *LADC*-264). The

materials used were −170 mesh gold powder prepared by precipitation and beryllium powder ball-milled to −400 mesh fineness. The press assembly was heated at 310-350° C. (590-662° F.) for one hour, and the powders were pressed at 55 tsi and ejected immediately. The compacts were 98% dense, and had a Rockwell B hardness of 88-92.

(4123) Behavior of Compacted Silver Powder and Mixtures of Gold and Silver Powders with Other Powders during Sintering. E. Raub, and W. Plate, *Met. Powd. Rept., 3,* No. 1, 8; *Oesterr. Chem. Ztg., 49,* No. 10/11, 190 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 4. When silver powder is compacted, cold welding occurs and is accompanied by a sudden increase in the coefficient of thermal expansion due to evolution of gases. Binary mixtures were sintered; on mechanical mixtures (Ag-Ni, Ag-Fe) no special changes were observed, but the formation of solid solutions (Au-Ni, Ag-Cu) was manifested by sharp increase in thermal expansion.

(4124) Effects of Sintering of Pressed Silver Powders. E. Raub, and W. Plate, *Z. Metallkunde, 40,* No. 5, 171-5 (1949). Thermal expansion, electrical resistivity and microstructure of pure silver and alloys containing up to 2% Cd, Zn and Sn were investigated.

(4125) Sintering Performance of Compacted Binary Mixtures of Gold and Silver Powders with Other Metal Powders. E. Raub, and W. Plate, *Z. Metallkunde, 40,* No. 6, 206-14 (1949). The sintering is studied by dilatometric measurement, and the data are supplemented by electrical resistivity measurement, and by x-ray diffraction studies.

D. Light metals and alloys

(4126) Protection from X-Ray Radiation in Diagnostics with Reference to Different Radiations and the Metal Beryllium. K. W. Hausser, A. Bardehle, and G. Heisen, *Fortschr. Röntgenstr., 35,* No. 12, 636-647 (1926). 1-2 mm. thick plates, pressed from beryllium powder and sintered near the melting point of the metal, were used as windows for X-ray protection tubes.

(4127) The Refining of Metals by Evaporation. W. Kroll, *Metallwirtschaft, 13,* 725-31 (1934). Beryllium powder is produced by vacuum distillation, and the condensate is fused or sintered into solid, brittle bodies.

(4128) The Vacuum Distillation of Metals. W. Kroll, *Metal. Ind. (London), 47,* 29-31 (1935). Beryllium powder is produced by vacuum distillation, and the condensate is fused or sintered into solid, brittle bodies.

(4129) Thermal Extraction of Beryllium. E. J. Groom, *Light Metals, 1,* No. 6, 203-204 (1937). The success attending the thermal extraction of Mg has reawakened an interest in the application of similar processes to Be. Be in powder metallurgy; apparatus for sintering of Be powder.

(4130) Powder Metallurgy: The Position of Aluminum. W. D. Jones, *Aluminum & Non-Ferrous Rev., 3,* 118-20 (1938). High pressure and high temperature assisted by high compression ratio cause breakage of oxide films and fritting of particles in the processing of aluminum compacts.

(4131) Aluminum and Magnesium Scrap in Powder Metallurgy. H. W. Jones, *Light Metals, 1,* 166-167 (1938). A survey of the possibility of utilizing grindings as a raw material for the preparation of Al and Mg in the form of compressed compacts from these powders and also from alloy powders.

(4132) Metalloceramic Aluminum. M. S. Denisova, and Ya. B. Fridman, *Vestnik Metalloprom., 20,* No. 11, and 12, 71-72 (1940); *Chem. Abstr., 35,* 5075 (1940). Tests on compacted and sintered Al powder specimens.

(4133) Properties of Compressed and Heated Aluminum Alloy Powder Mixtures. L. W. Kempf, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chapt. 29, pp. 314-316. Alloys made by atomizing, include 90-10 Al-Mg; 90-10 Al-Zn; 90-7-3 Al-Zn-Mg, and 95-5 Al-Cu.

(4134) Powder Metallurgy of Aluminum. G. D. Cremer, and J. J. Cordiano, *Trans. Am. Inst. Mining Met. Engrs., 152,* 152-165 (1943). February Meeting.

Atomization best method for making elemental Al-powder. Lubrication of dies important. Specimens produced by compression and sintering were found to be inferior to wrought or cast material, but several grades of atomized elemental Al-powders compacted at higher pressure produced specimens with properties comparable to those of wrought, annealed commercial Al. Experiments were also made with Al-alloy composition containing 2.5% Cu, 0.5% Mg, bal. Al.

(4135) Mechanical Ingoting of Aluminum and Magnesium Turnings. M. Stern, *Iron Age, 152,* No. 7, 90-92 (1943). Scrap reclamation by simultaneous pressing into a heated steel die and sintering pulverized assorted turnings.

(4136) Aluminum and Magnesium in Powder Metallurgy. J. J. Cordiano, *Aluminum & Magnesium, 1,* No. 3, 22-23, 28 (1944). Application and properties of atomized Al for powder metallurgical purposes. No important application for Mg found in powder metallurgy to date.

(4137) Aluminum Powder. C. Hardy, *Metal Ind. (London), 66,* No. 2, 22 (1945). The specimens for test bars were prepared from atomized Al powder mixed in various proportions with electrolytic Cu, Mn and Al-Mn alloy powders; the results are given in a table.

(4138) Sintered Beryllium for X-Ray Tube Windows. F. C. Kelley, *Iron Age, 156,* No. 4, 68-9 (1945). Process of pressing and sintering coarse Be powder described for production of x-ray windows.

(4139) Magnesium Powder Metallurgy Progress. R. Fellom, Jr., *Light Metal Age, 4,* No. 2, 7 (1946). The main difficulty of removing the magnesium oxide film from the surface of the particles is discussed, and means of its reduction are cited.

(4140) Beryllium and Its Alloys. G. Oldham, *Mining Ind. (London), 227,* 531-32 (1946). Production and use of Be and Be-alloys. Treatment of ores. Be-Cu alloys produced directly by a thermal reduction process involving powders. Applications for safety tools in mines.

(4141) Treatment of Distilled Pure Magnesium and Its Properties. F. Sauerwald, and I. G. Farbenindustrie A. G., F. D. Rept. No. 1420/46 (1946). Mg in form of lumps, obtained by condensation, was extruded at 420-280° C. (790-535° F.) and at different speeds, then rolled to avoid intermediate smelting. Process developed and reported in 1942.

(4142) Aluminum Components. R. L. Bickerdike, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 185-191; *Met. Powd. Rept., 1,* No. 12, 183 (1947). Mixture of −200 mesh Al powder with 68% −300 mesh,, and 6% electrolytic Cu powder pressed at 50 tsi. Sintering at 500-620° C. (930-1145° F.), for 20 hrs. in H or vacuum. Quenching in water at 500° C. (930° F.) and age-hardening at room temperature complete treatment. Properties given.

(4143) Aluminum-Carbon Alloys. H. Y. Hunsicker, and L. W. Kempf, *Quart. Trans. Soc. Automotive Engrs., 1,* No. 1, 6-8 (1947). A 90-10 Al-C made from an aluminum-graphite powder mixture sintered at 600° C. (1110° F.) gave fairly good strength and disclosed the compound Al_4C_3 in the microstructure.

(4144) Synthetic Bodies from Light Metals. F. Sauerwald, *Arch. Metallkunde, 1,* No. 7/8, 363-368 (1947). Al with 9% Mg and Mg with 9% Al were compacted at 20 tsi into rods and sintered in argon, then quenched with water and extruded. Tensile strength, shrinkage, elongation are of the same order as that for cast alloys; with an increasing sintering temperature increased the strength of Mg-alloy, but Al-alloy decreased.

(4145) Pressing of Aluminum Powder. Studiengesellschaft Hartmetall. F. D. Rept. No. 3908/47 (1947). Aluminum powder was best hot-pressed at 100° C. (212° F.) and 3000 kg./mm.^{2} followed by heat-treatment at 600° C. (1110° F.) for 5 hours, forging at room temperature and annealing at 600° C. (1110° F.) for 6 hours. Grain growth was marked, but the porosity very low. (In this report of 1942 the material is also referred to as "Aluminumbronze").

(4146) Powder Metallurgy of Light Metals. E. Nachtigall, *Berg- und Hüttenmännische Monatshefte, 93,* No. 8/11, 214-9 (1948). Review of present status of powder metallurgy of light metals; photomicrographs, tables. Bibliography.

(4147) The Position of Light Metal Powder Metallurgy. E. Nachtigall, *Met. Powd. Rept., 3,* No. 1, 5; *Oesterr. Chem. Ztg., 49,* No. 10/11, 191 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 30. The author first reviewed work on sintered light alloy compacts from which it was concluded that they were not interesting. On the other hand, he saw considerable possibilities in mixing light metal with graphite, oxides or hard metals. By means of powder metallurgy it would be possible to use Al or Al alloys with graphite in any composition.

(4148) Designing for Production of Aluminum Parts by Powder Metallurgy. J. L. Bonanno, *Steel, 125,* No. 8, 68-70, 72, 74, 77 (1949). Owing to the difficulty of pressing Al powder the development of Al powder metallurgy has been relatively slow. Two methods have been devised to minimize the tendency of Al powder to seize against the die walls.

(4149) Process for Hot Pressing Beryllium Powder. A. U. Seybolt, R. M. Linsmayer, and J. P. Franssen, *U. S. Atomic Energy Comm. Publ. 2679,* 1949, 23 pp. Almost fully dense compacts were product.

(4150) Sintering of Aluminum Alloys. A. von Zeerleder, *Versammlg. Ges. Metallkunde Goslar, 4,* IX (1949). The sintered aluminum and aluminum alloys are superior to cast Al products in many instances.

E. Low melting metals and alloys

(4151) New Method of Forming Alloys. W. Hallock, *Z. physik. Chem., 2,* 378-79 (1888). Wood's metal made from finely divided metals by pressure and subsequent treatment at slightly elevated temperatures.

(4152) The Properties of Cold-Worked Metals; the Density of Metallic Filings. T. M. Lowry, and G. R. Parker, *J. Chem. Soc., 107,* 1005-1018 (1915). Zinc chips are pressed at 35 to 50 tsi to plates for batteries, etc., having a density comparable with that of the molten metal.

(4153) Chemically Pure Powdery Mercury. F. Kraus, and K. Mählmann, *Z. anorg. allgem. Chem., 184,* 298-302 (1929). Under certain conditions the reduction of mercuric nitrate by hydrazine hydrate or ferrous sulfate gives a fine powdered substance containing 99.8% Hg.

(4154) Powder Metallurgy of Tin. H. C. Watkins, *Metals & Alloys, 15,* No. 5, 751-757; *Metal Ind. (London), 61,* 146-49 (1942). Discusses manufacture and uses of Sn and alloys powders, including bearings and solders.

(4155) Substitute Metals for Plain Bearings. Vereinigte Deutsche Metallwerke. F. D. Rept. No. 1544/47 (1947). Development of a zinc alloy bearing from powder as a substitute for Cu, but was not regarded as promising. *Cf.* B.I.O.S. Final Rept. No. 1159.

(4156) Processing of Zinc Powder. W. Wolf, *Arch. Metallkunde, 1,* No. 7/8, 361-63 (1947). Pressing and sintering experiments with pure zinc and zinc-alloy powders containing copper and/or aluminum; physical properties and alloy formation studied; description of experimental procedure and apparatus.

7. POROUS PRODUCTS

(4157) Artificial Porous Metal Bodies. W. Machu, *Kolloid-Z., 88,* 251-56 (1939). A review of patents of bearings, catalysts, filters and infiltration.

(4158) Metal Sponges. C. Claus, *Metal Progress, 46,* No. 3, 473-75 (1944). Porosity is an inherent property of powder compacts and reduced or eliminated only by expensive operations. Controlled porosity and permeability are the prime object of producer's art. Review of underlying principles in manufacture and operation of porous bearings and porous filters.

(4159) Small Parts Made by Powder Metallurgy. H. W. Greenwood, *Iron Coal Trades Rev., 157,* No. 4150, 613-4 (1947). Porous parts, such as self-oiling bearings, filters, and de-icing equipment are considered.

A. Bearings and Bushings (copper-base, iron-base, aluminum-base)

(4160) A New Synthetic Bearing Metal. *Chem. & Met. Eng., 25,* No. 5, 207 (1921). Porous bearing pressed from metal powders obtained from reduced oxides. Genelite development by General Electric Co.

(4161) Genelite—An Improved Bearing Alloy. E. G. Gilson, *Gen. Elec. Rev., 24,* 949-51 (1921). A description is given of a porous bearing impregnated with oil, called Genelite. It is a synthetic bronze containing finely divided graphite uniformly distributed throughout its mass. The oxides of the metal are mixed with graphite and the reduced powder is then pressed. The finished bearing will absorb 2-3% by weight of oil.

(4162) Genelite—A New Bearing Metal. E. G. Gilson, *Machinery (N.Y.), 29,* 123 (1922). Produced by mixing powdered graphite with powdered oxides, to reduce 0 and leaving the desired amount of graphite after the reduction; pressing the partially reduced powder in steel molds to the desired shape.

(4163) Bearings of Porous Bronze. *Génie civil, 98,* 404 (1931). "Compo" bearings consisting of porous bronze saturated with oil. The composition is a true alloy having crystalline structure.

(4164) Bearings that Lubricate Themselves. D. A. Clark, *Metal Ind. (N.Y.), 30,* 294 (1932). Oilite bearings, products of the Chrysler Corp., are described.

(4165) Compo Bearings. *Automobile Eng., 23,* No. 308, 347 (1933). Oil retaining bushes of phosphor-bronze with 40% porosity are produced as die-pressings, which withstand a pressure of 75,000 psi.

(4166) Capillary Lubrication by Means of Oil-Containing Bronze. *Machinery (London), 42,* No. 1078, 282-284 ((1933). The amount of oil exuded due to the closing up of the capillary tubes by squeezing is astonishing, and the bush will not break, but will belly out until barrel shaped, thus proving its great ductility.

(4167) Oilite—An Oil-Containing Bearing Bronze. *Metal Ind. (London), 42,* No. 16, 430-31 (1933). The matrix is a virgin metal, *e.g.,* Cu-Sn alloy and takes a high surface finish; the lubricant can be of almost any desired quality.

(4168) Metal Bearings with Permanent Lubrication. M. Moldenhauer, *Umschau Wissenschaft Technik, 37,* 1003-5 (1933). Review of porous bearings, their constitution, structure, properties; mechanism of self-lubrication.

(4169) Methods of Preparation of Graphitized Metals and Alloys. M. P. Slavinskii, and A. C. Tumarev, *Metallurg, 8,* No. 4-5, 70-91 (1933). Physical tests on finished specimens. Antifriction bronze containing graphite, produced from powders, were briquetted and heated to a temperature between the solidus and liquidus state in hydrogen.

(4170) Minimizing Bearing Troubles with Self-Lubricating Bronze Bushings. *Machinery (London), 45,* 483-86 (1934). Porous bronze bearings are described.

(4171) Porous Bearings. *Technische Blätter (Düsseldorf), 24,* 760 (1934). Application of capillary metals made by sintering.

(4172) Minimum Bearing Troubles with Self-Lubricating Bronze Bushing. H. Chase, *Machinery (N.Y.), 40,* No. 1, 9-12 (1934). Porous metal bearings discussed, especially from standpoint of performance.

(4173) Casting and Welding or Pressing and Sintering. J. Mehrtens, *Z. Automobiltechnik, 37,* 131-2 (1934). Uhlmann's process of making porous bushings is described; properties of sintered bronze are discussed.

(4174) The Uhlmann Capillary Metal (Sinter Bronze) for Bearings and Bushings. J. Mehrtens, *Giesserei, 55,* 53-4 (1934). Use of porous bearings described.

(4175) Oil-Saving and Oil-Less Bearings. G. Baum, *Öl u. Kohle, 11,* 697-99 (1935). A graphitized bronze has excellent bearing properties. Oil-impregnated wooden bearings are improved by forcing metal powder into the wood prior to impregnation.

(4176) Porous Bronzes. A. Chaplet, *Cuivres et Laiton, 8,* 502-3 (1935). Porous bearings are explained, and applications listed.

(4177) Metallographic Examination of Graphited Articles of Metalloceramic Type. N. M. Zarubin, *Zavodskaya Lab., 4,* 1474-7 (1935). Metallized graphite bearings investigated, and structure and properties discussed.

(4178) Bearings that Need Not Be Oiled. *Am. Machinist, 80,* 490-3 (1936). Oilite bearings, products of Amplex Div., Chrysler Corp. are described.

(4179) Anti-Friction Metals. *Métaux, 11,* 225-327 (1936). Discussion includes porous bearings.

(4180) Self Lubricating Bearings. *Tech. Zentr. prakt. Metallbearbeitung, 46,* No. 23, 837-40 (1936). Consisting of graphited asbestos, or bronze powder sintered with graphite, or copper-tin powdered mixture with graphite, sintered and immersed in oil.

(4181) New Materials and Processes in the Field of Engineering. L. W. Johnson, *J. Inst. Production Engrs., 15,* No. 12, 645-90 (1936). Discussion includes porous bearings, especially from copper powder mixtures.

(4182) Anti-Friction Properties of Copper Alloys. P. Laurent, *Métaux, 11,* No. 136, 267-69 (1936). A review of metallography of brasses, bronzes, copper-lead alloys, aluminum bronzes, porous bronzes.

(4183) Self-Lubricating Bronze Bearings. *Elec. Times, 92,* 332 (1937). Oilite bearings and other types of porous products discussed.

(4184) Interdiffusion of Copper, Tin and Graphite Powders. T. Ishikawa, *Nippon Kinzoku Gakukai-Shi, 1,* No. 6, 226-31 (1937). Sintering compressed porous bearing alloys of Cu, Sn and graphite described in detail.

(4185) Copper Alloys as Bearing Materials. D.P.C. Neave, and W.B. Sallit, *Metal Ind. (London), 51,* No. 16, 377-80 (1937). Reference is made to powder metallurgy bearings containing 90% Cu and 10% Sn.

(4186) Graphite Bronzes. A. I. Schpagin, *Trudy Tsentral. Gosudarst. Namh. Issledovatel. Inst. Sbornik, Rabot Metalloobrabotke i Splowam,* 1930-1934, 217-226 (1937); *Chem. Zentr., 110,* Pt. I, 4111 (1939). Porous copper-graphite-zinc alloys described. For the production of graphite containing alloys it is necessary to use Cu-powder which is annealed at 400° C. (750° F.). A pressure of 20-30 kg./mm.^{2} and an annealing temperature of 700° C. (1290° F.), reached by slowly heating up, are necessary for compositions of 50% Cu and 50% graphite; or 79% Cu, 10% Zn, 11% graphite.

(4187) Sintering of Copper and Tin Powders. H. E. Hall, *Metals & Alloys, 10,* No. 10, 297-98 (1939). Porous bronze bearings discussed and colored micro-photographs shown.

(4188) R. Kühnel, *Werkstoffe für Gleitlager.* Springer, Berlin, 1939, 427 pp. On pp. 408-420 sintered metal bearings are discussed within the frame of a general survey on materials for bearings.

(4189) H. Mann, in R. Kühnel, *Werkstoffe für Gleitlager.* Springer, Berlin, 1939. Sintered bearings are treated on pp. 408-421. Special dies are illustrated which enable the pressing of bushings of very thin walls.

(4190) Porous Bearings. M. Yu. Bal'shin, and N. G. Korolenko, *Vestnik Inzhenerovi Tekh.,* No. 5, 312-317 (1940); *Chem. Abstracts, 34,* 7236 (1941). Tabulated data are given on the properties, antifriction characteristics, lubrication and operating features of bearings made from porous metals.

(4191) Sintered Powdered Metals Help Make High Grade Bearings. C. M. Heath, *Steel, 107,* No. 16, 162-63 (1940). Bearings for aircraft, and, in particular, Rolls-Royce type Al-Sn bearings are discussed.

(4192) Development and Testing of Bearings. O. H. Hummel, *Metallwirtschaft, 19,* No. 41, 683-91 (1940). Testing of bearing materials relates to porous sintered bearings.

(4193) Sintered Metal Bearings. O. Hummel, *Metallwirtschaft, 19,* No. 44, 979-83 (1940). Preparation, properties, and uses of sintered porous bronze bearings are discussed.

(4194) A Modern Bearing Alloy by Powder Metallurgy. M. Köhler, *Demag Nachr.,* **B14,** 29-35; also *Chem. Zentr., 112,* Pt. II, 2994 (1940). Bearing alloy "Pressko" made from sintered Fe and varying amounts of C consists of ferrite, pearlite and cementite, is an excellent substitute for bronze and red brass. Material may vary in degree of porosity.

(4195) Powdered Metal and Bakelite Bearings. M. Melhuish, *Engineer, 170,* No. 4422, 240-41 (1940). After sintering the bronze powder, bearings are immersed for a short time in a heated mineral oil; bearings for heavy pressure are made from laminated fabric impregnated with synthetic resin.

(4196) Bearing Metals and Their Suitability for Modern Requirements. M. Melhuish, *J. Inst. Automobile Engrs. (London), 9,* No. 1, 1-12 (1940). Oil-impregnated porous powder metal bearings are mentioned in the review.

(4197) Self-lubricating Bearings Produced by Powder Metallurgical Means. P. E. Wretblad, *Tekn. T. Stockholm, 70,* No. 37, 357-59 (1940). A review, including discussion of porous bronze and iron-base bearings.

(4198) Self-lubricating Bushes. *Automobile Engr., 31,* No. 413, 248 (1941). Manufacture and applications.

(4199) Porous Bronze Bearings. *Metals & Alloys, 13,* No. 6, 753 (1941). Commercial notice by Keystone Carbon Co., St. Marys, Pa. Illustration of several new shapes shown.

(4200) Porous Metal Bearings. *Product Eng., 12,* No. 9, 496-500 (1941). Self-lubricating bearings benefiting by advance in powder metallurgy.

(4201) Replacement of Tin in Bearing Metals. H. W. Gillett, H. W. Russell, and R. W. Dayton, *Metal Ind. (London), 58,* No. 10, 226-30; No. 11, 254-56 (1941). Powder metal bearings discussed among others.

(4202) Oil-Retaining Bronze Bearings. W. R. Lewis, *Tin Research Inst. Leaflet, Tin and Its Uses, No. 10,* 13-14 (1941). Describes production, features and life of porous, self-lubricating bronze bearings; details of analysis and properties given for one type, product of The Bound Brook Bearing Company, Bound Brook, N.J., and British Bound Brook Bearing Company, Birmingham, England.

(4203) Comparison Tests With Lubricated Substitute Materials and Bronze Bearings. O. Neuse, *Stahl u. Eisen, 61,* No. 18, 459-60 (1941). Substitute materials refer to sintered iron.

(4204) Porous Sintered Bearings. O. Neuse, *Techn. Mitteilungen Essen,* No. 3/4, 17-25 (1941); *Demag Nachr., 15,* 4-11 (1941). Production and properties of porous, sintered iron-lead bearings are described; the lead is preferably added as the oxide which is reduced by the graphite added as a lubricant. Powdered iron sulfide additions are also referred to.

(4205) Porous Iron Bearings. *Metals & Alloys, 15,* No. 2, 273 (1942). Keystone Carbon Co. "Selflube" porous iron bearings announced, and pictures of products shown.

(4206) Oil-Retaining Bronze Bearings. *Passenger Transport J., 87,* No. 2210, 282-83 (1942). Oil-retaining bronze bearings made by high pressure die pressing of pure electrolytic finely divided Cu and Sn, so that metal is porous and can absorb up to 30% by volume of lubricating oil.

(4207) Oil-Retaining Bronze Bearings. W. R. Lewis, *Indian Eng., 111,* 73-74 (1942). Advantages of powder metallurgy process in producing them are described; a composition of 88% Cu, 9.7% Sn, 1.4% graphite is mentioned in particular.

(4208) Sleeve Bearing Metals in Light Engines under Extreme Service. H. Lüpfert, *Forsch. Gebiete Ingenieurw., B13,* No. 417, 28 pp. (1942). Oil-absorbing sintered metals preeminently suitable in light household and industrial equipment. Review of wearing qualities.

(4209) Sintered Iron for Bearings and Drives in Machine Tool Construction. W. Reuthe, *Maschinenbau, Der Betrieb, 21,* 161-3 (1942); *Chem. Zentr., 113,* Pt. II, 1171-2 (1942). This subject is included in a discussion of iron powder parts.

(4210) Sliding Bearings of Powdered Metal. E. Rohde, *Z. Ver. deut. Ing., 94,* No. 85, 834-36; *Chem. Zentr., 113,* Pt. I, 1182 (1942). Application of powdered metal products for sliding bearings are reviewed.

(4211) Selecting Bearings. C. R. Underhill, *Elec. Mfg., 30,* 43-46, 112-122 (1942). Long article on different kinds of bearings. Oilless bearings made by powder metallurgy described in detail, bronze, graphite, alloys, iron and others.

(4212) Powder Metals Find Wide Use. *Am. Machinist, 87,* No. 13, 83-86 (1943). The use of iron-copper and pure iron self-lubricating bearings of close dimensional accuracy are described.

(4213) Iron-Base Sintered Metal Powders With Special Reference to Bearing Materials. O. Hummel, *Metallwirtschaft, 22,* No. 13/14, 206-10 (1943). Principal types of sintered irons, classified according to porosity and mechanical strength. Trends in application and main uses. Gears. Relationship between porosity and lubrication. Other data include hardness tests and weldability, load-carrying capacity at different temperatures.

(4214) Copper-Lead Bearings by Powder Metallurgy. W. D. Jones, *Metallurgia, 28,* No. 168, 255-60 (1943). This alloy represents peculiar casting difficulties. Attention is directed to manufacturers of this alloy in form of porous bushings or bonded on steel backing by technique of powder metallurgy. Results of investigation described.

(4215) Investigations of Porous Bearings. G. Wassermann, and R. Weber, *Metallwirtschaft, 22,* 201-6 (1943). Performance test results. Production of Al, Cu, Fe, or Zn-base bearings from metal powders.

(4216) Modern Bearing Materials. F. Wehrmann, *Gas u. Wasserfach, 86,* 420-1 (1943). Advantages and chief disadvantages of German bearing substitute metals such as Zn and Pb alloys, synthetic resin bearings and sintered and cast iron bearings.

(4217) Manufacture and Applications of Porous Bronze Bearings. *Ind. Power & Production, 20,* No. 219, 10-12 (1944). Detailed information regarding manufacture and conditions under which porous bronze bearings can be used successfully; "Reservoil" bearings are made of typical anti-friction material of about 90% Cu, 10% Sn composition; for most applications, porosity of about 30% is suitable; "Reservoil" bearings should not be run above 100° C. and when used at temperatures approaching this should be provided with supplementary lubrication; applications suggested.

(4218) Metal Powder Bronze Gun Bearing. *Metals & Alloys, 20,* No. 1, 212 (1944). Self-lubricating bronze gun bearing made by Amplex Div., Chrysler Corp.

(4219) Powder Metallurgy. R. C. Gregory, *City Coll. Vector, 7,* 50-1 (1944). A flow diagram shows the steps in the manufacture of self-lubricating bearings.

(4220) Bearing Capacity of Bearings Made of Sintered Iron. E. Heidebroek, *Z. Ver. deut. Ing., 88,* No. 15/16, 205-207 (1944). Bearing capacity of Fe-powder bearings. Report on systematic tests to determine suitability of different sintered Fe products and factors governing their more extensive use as bearing metal.

(4221) Iron Powder Bodies for Bearing Races. H. Odenhausen, *Anz. Maschinenwes., 66,* 3 (1944); *Chem. Zentr., 115,* Pt. II, 154 (1944). Description of manufacture and properties of porous sintered iron bearing races.

(4222) Mechanical Properties of Sintered Iron for Porous Bearings. H. Unckel, *Arch. Eisenhüttenwesen, 18,* No. 5-6, 125-130 (1944). Study of porous sintered specimens for density, Brinell hardness, tensile strength, behavior in compression, notched bar impact, microstructure and oil absorption.

(4223) Tests with Porous Sintered Copper-Base Alloys for Bearings. H. Unckel, *Z. Metallkunde, 36,* No. 7, 164-169 (1944); *Chem. Abstr., 41,* No. 8, 2374 (1947). Use and different kinds of porous metal bearings are described. Porous Cu-base alloys containing graphite, Sn, Pb, Fe, and Zn were produced under various pressures and sintered at 600-950° C. (1110-1740° F.) for 2-3 hrs. in air, vacuum and controlled atmosphere. When sintering pure Cu compacts in an atmosphere containing zinc vapor, a brass layer was formed on the surface of the compact. Observations during pressing and test results are given.

(4224) Sintered Iron. *Automobile Engr., 35,* 400 (1945). The carrying capacity of porous sintered iron when used for bearing liners is discussed.

(4225) Powder Metallurgy. R. Girschig, *Rev. mét., 42,* 218-25 (1945). A description is given of an apparatus, designed by the author, used for the testing of porous bearings.

(4226) Backbone of Engineering. F. P. Peters, *Sci. American, 172,* No. 2, 95-97 (1945). Development of metals and alloys, new materials. Self-lubricating bearings made by powder metallurgy are discussed.

(4227) Bearings from Metal Powders. W. R. Toeplitz, *Trans. Am. Inst. Mining Met. Engrs., 161,* 542-49 (1945). Effect of porosity on structure and physical properties of porous bearings, installation of bearings, diagrams. Discussion.

(4228) 200-Lb. Bearing now Being Made from Metal Powders. F. G. Wayman, *Metal Rev., 18,* No. 7, 2 (1945). Report on talk by G. E. Patzer of Amplex Div. Oilite bearings as large as 18 in. in diameter and others weighing more than 200 lbs. are now produced by powder metallurgy by Chrysler Corp.

(4229) F. D. Rept. No. 2527/46 (1946) (formerly H.E.C. 12366). Articles on Sintered Iron Bearings Contained in VDI – Special Issue, on "New Constructional Materials," in VDI-Zeitschrift, 1942.

(4230) Powdered Metal Cold Formed into Porous Bearings. *Product Eng., 17,* No. 10, 98 (1946). Cold pressed powdered metal bearings formed without sintering are made by Diamond Hone & Wheel Co., New York. They are oil-impregnated and used in a diamond radius wheel dresser.

(4231) Aluminum Alloy Bearings for Heavy Duty Applications. H. R. Clauser, *Materials & Methods, 24,* No. 3, 633-36 (1946). A development of a self-lubricating porous powdered aluminum alloy bearing by the Amplex Division of Chrysler Corporation during the war is reported.

(4232) Talk on Bearings Includes Newer Types, Cd-Base, Al-Base, Powder Metal. G. H. Dinges, *Metals Rev., 19,* No. 1, 5 (1946). Report on talk by G. J. LeBrasse in Milwaukee.

(4233) Methods of Producing Powdered Metals and Their Uses. Düsseldorfer Eisenhüttengesellschaft. F. D. Rept. No. 1709/46 (1946). An account in English in 1946 of the manufacture of sintered iron bearings from Hametag powder.

(4234) Bearings Development up to Date. H. W. Luetkemeyer, *Metal Progress, 50,* No. 5, 918 (1946). Abstract from paper presented before Cleveland Section of S.A.E., May 17, 1945. Metal powder bearings are considered for rod and main bearings. Usual porous bronze compositions yield unsatisfactory fatigue strength and storage of oil volume; have resulted in development of composite steel back bearings with Babbitt liner.

(4235) Bearing Properties of Sintered Metals. Metallgesellschaft A. G. F. D. Rept. No. 1310/46 (1946). The alloys were made from powders produced in the D. P. G. process. Reported in 1940.

(4236) Manufacture of Cylindrical Bushes. Metallgesellschaft A. G. F. D. Rept. No. 1319/46 (1946). Bushes are made by sintering a number of shell driving bands together. Reported in 1943.

(4237) Engineering Bronzes. K. Rose, *Materials & Methods, 23,* No. 4, 1027-1042 (1946). Introduction, general classification, non-hardenable bronzes, hardenable bronzes, fabricating the engineering bronzes and forms and finishes. On page 1033 self-lubricating bearings by powder metallurgy.

(4238) Sleeve Bearing Industry of Germany (Powder Metal Bearings.) C. E. Swartz, and F. H. Ragan, F.I.A.T. Rept. No. 666 (1946). The Demag Company produced 50-70 tons of tank bearings per month, the composition being 94% iron, 1% carbon, 5% lead. Promising experimental results had been obtained with 60/40 Fe-Pb bearings.

(4239) Sintered Iron Bearings. Vereinigte Deutsche Metallwerke. F. D. Rept. No. 2525/46 (1946) (formerly H.E.C. 12386). A good technical sales article by O. H. Hummel, written in 1942.

(4240) Self-Lubricating Bearings Made by Powder Metallurgy. M. T. Victor, *Elec. Mfg., 37,* No. 2, 123-25, 210, 212, 214 (1946). Structure function, applications and requirements of porous bearings are reviewed.

(4241) Manufacture and Anti-Friction Properties of Sintered Bearings. G. Wassermann, R. Deber, and Metallgesellschaft A. G., F.D. Rept. No. 1303/46 (1946). Aluminum alloy bearings tested in 1944 by using forced lubrication. Compositions of 95% Al, 5% $FeAl_3$; 95% Al, 5% $CuMg_2$; or 95% Al, 5% Al_5Mn operated at lower temperature than Cu-Pb bearings.

(4242) Development of Graphitic-Ferritic-Pearlitic Sintered Iron Bodies for Bearings. H. Wiemer, U.S. Dept. Comm. PB. 14762, 2 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 17, 937 (1946). Experiments have shown that graphite and iron will combine in any proportion by sintering in vacuo, and at temperatures over 1000° C. (1830° F.).

(4243) Substitution of Plain Bearings for Roller Bearings. Ammoniakwerk Merseburg G.m.b.H., Leuna. F.D. Rept. No. 317/47 (1947). Recommendations compiled by the German Ministry of Supply in 1944 include powder metallurgy products.

(4244) Structure of Porous Bronze Bearings. A. Carter and A. G. Metcalfe, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp. 99-105; *Met. Powd. Rept., 1,* No. 11, 172 (1947). X-ray diffraction method used for studying structure of three commercial types of porous graphited bronze bearings, and of experimental bearings made of coarse and fine powder.

(4245) Two Products of Powder Metallurgy. J. C. Ceccaldi, *Machines et Métaux, 31,* No. 351, 375 (1947). Porous filters and bearings of metal powders are described.

(4246) Development of Sintered Bearings. F. Eisenkolb, *Arch. Metallkunde, 1,* No. 7/8, 345-352 (1947). Review of German literature on performance of sintered porous bronze and iron bearings.

(4247) Tests of Bearings Made of Sintered Iron in 1944. Friedr. Krupp A. G., Essen. F.D. Rept. No. 1303/47 (1947). One report deals with pressing experiments on a toggle press in which a vibrating force (5400 c.p.m.) was superimposed upon the die. The data are insufficient for any general conclusions to be drawn. A diagram of the equipment is given. In another report, sintered iron bearings compared unfavorably with bearings of the usual materials, as scoring occurred through the large size of the iron particles.

(4248) Material for Sliding Bearings. St. Fronius, *Arch. Metallkunde, 1,* No. 7/8, 352-356 (1947). Author shows effect of type of powder (Hametag, atomized, oxide reduced) upon bearing performance. Aluminum alloy bearings passed tests but are not used in practice. Discussion of the oil storage in porous sintered materials.

(4249) Manufacture of Products from Metal Powders. A. G. Haffenden, U. S. Dept. Comm. PB. 63601/1946, 18 pp.; *Bibl. Scient. & Ind. Rept., 5,* No. 1, 19 (1947). Iron-base bearings could take heavy loads at low speeds, but were less suitable for high speeds. *Cf.:* B.I.O.S. Final Rept., 908 (1947).

(4250) Expression of Lubricating Power as a Function of the Bearing Capacity. E. Heidebroek, *Arch. Metallkunde, 1,* No. 7/8, 356-59 (1947). A theoretical investigation of the subject, with reference to self-lubricating porous bearings made.

(4251) Metal Powder: Self-Lubricating Bearings. A. J. Langhammer, *Iron & Steel Eng., 24,* No. 1, 93 (1947). Review of the advantages of self-lubricating bearings made from powder compacts, particularly high purity tin-bronzes.

(4252) Porous Bearings. A. J. Langhammer, *Modern Metals, 3,* No. 5, 13-14 (1947). Review of powder metallurgy bearings research at Amplix Division of Chrysler Corp.

(4253) Bearings, Bushings and Allied Products. A. J. Langhammer, *Proc. Third Ann. Spring Meeting, Met. Powd. Assoc.,* New York, May 27, 1947, pp. 32-34. Majority of self-lubricating bearings are of a 90-10 bronze composition, Cu and Sn being virgin, and of high purity. Other bearings are of Fe and Fe alloys. Quality of raw material is of extreme importance.

(4254) Powder Metallurgy Bearings Materials. W. H. Tait, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Rept. No. 38, London, 1947, pp.

157-161; *Met. Powd. Rept., 1,* No. 12, 181 (1947). A note on powder metallurgy methods used in Great Britain for the manufacture of plain bearings and thrust washers. Properties of porous bearing materials summarized in two claims for superiority: (*1*) assurance of structure of desired type, texture, and composition, and (*2*) reduction in wastage. Appendix deals with the influence of structure on the behavior of copper-lead bearings; the influence of elastic modulus on bearing behavior.

(4255) Self-Lubricating Bearings by Powder Metallurgy. M. Victor, *Can. Metals Met. Inds., 10,* No. 4, 18, 38 (1947). Advances of powder metallurgy over orthodox methods in manufacture of bearings and bushings discussed.

(4256) Manufacture of Cylindrical Bushes at Metallgesellschaft A. G., G. Wassermann, F.D. Rept. No. 1319/46 (1946), 3 pp.; *Met. Powd. Rept., 1,* No. 5, 75 (1947). Process consists of sintering five shell driving bands together into a cylinder after the contact surfaces have been coated with a thin iron powder slurry.

(4257) Properties of Sintered Bearings. R. Weber, F.D. Rept. No. 1310/46 (1946), 18 pp.; *Met. Powd. Rept., 1,* No. 5, 75 (1947). Tests were made by Metallgesellschaft A. G. in 1940 with forced lubrication at speeds of 5, 11.5, and 14.7 ft./sec. on different compositions, mostly Al-base, but also including Cu-Pb alloys. In the latter case self-lubrication is only possible at a maximum speed of 20 in./sec. and loads of 400-1400 psi. Good results were obtained with Al plus 5-10% Al_3Fe and Al plus 15% Pb; also with Al plus 5% $CuMg_2$ and Al plus 5% Al_5Mn but then with slightly higher temperatures.

(4258) Development of Sintered Bodies of Graphite, Ferrite and Pearlite for Bearings. H. Wiemer, F.D. Rept. No. 4047/47 (1947). At the Kaiser Wilhelm Institut für Eisenforschung, porous compacts of Fe powder and 1% natural graphite were sintered in a 0.1 mm. Hg vacuum at 1000° C. (1990° F.) without formation of pearlite.

(4259) Processing of Zinc Powder. W. Wolf, *Arch. Metallkunde, 1,* No. 7/8, 361-3 (1947). It was found possible to produce porous zinc bearings by extrusion; also, to incorporate 6% graphite into the extruded product.

(4260) Pump Bushings by Powder Metallurgy. *Iron Age, 161,* No. 15, 94 (1948). Water pump bushings are made from copper and tin powder mixed with graphite and other lubricants, also added for the lubrication of the die; sintered in electrical furnace with propane atmosphere.

(4261) Pressed Articles from Sintered Iron. F. Eisenkolb, *Industrie Rundschau, 3,* No. 3, 2-4 (1948). A report on the production of pressed and sintered articles, especially of porous bearings.

(4262) Experiments on Corrosion Resistance of Porous Bronze Compacts. M. M. Hallett, *J. Soc. Chem. Ind., 67,* No. 1, 57-61 (1948). Test results using a range of acids, alkalis and salts, under aeration conditions in comparison with the resistance of solid bronze. The corrosion resistance of the two types did not differ greatly.

(4263) Porous Bronze Bearings. J. W. Lennox, and G. Brewer, *Metal Ind. (London), 73,* No. 22, 429-31 (1948). Powder inspection, mixing and pressing; design and selection of press tools; sintering and oil impregnation; properties of bronze bearings.

(4264) Porous Bushings – Results of Investigations on Bearing Properties. H. A. Unckel, *Metal Ind. (London), 73,* No. 4, 67-70 (1948). The results of data on the frictional characteristics of porous bronze and iron bushings in usual speed and loading ranges are given; comparison between bushings from porous bronze, sintered iron, and solid tin-bronze rod.

(4265) Bearing Testing as Applied to Porous Metal Powder Bearings. D. S. Urquhart, *Proc. Fourth Ann. Spring Meeting Met. Powder Assoc.,* Chicago, Apr. 15-16, 1948, pp. 59-69 (1948). The testing machines described indicate that (*1*) a porous metal bearing develops an oil film which is very persistent under loads; (*2*) a porous bearing will suck oil through the pores and supply it to the bearing surface; (*3*) the commonly used relationship PV = 50,000 for maximum load is a satisfactory criterion.

(4266) Recommendations for Exchange of Antifriction Bearings with Journal Bearings. E. Heidebroek, *Technik, 4,* No. 2, 53-6 (1949). Lubrication, load-carrying characteristics; evaluation of various bearing materials, cast iron, sintered iron, plastics, etc.

(4267) Sintered Bearings Instead of Ball-Bearings or Plain Bearings. W. Katz, *Metall, 3,* 295-96 (1949). A comparison of sintered porous material and compact material is given.

B. Filters

(4268) Sintered Metal Filters for the Purification of Concentrated Alkali Solutions. L. Schlecht, and G. Trageser, *Chem. Fabrik, 12,* No. 19, 243-44 (1939). A recent new development of porous metal structures from carbonyl nickel suitable for filters in the cleaning of concentrated lyes is described.

(4269) Porous Metal Filters. *Steel, 109,* No. 1, 96 (1941). Porex, a product of Moraine Products Division of General Motors, is capable of removing foreign materials from fluid, and of altering the characteristics of gases by diffusion.

(4270) Powdered Metal Product Used for Filtration and Flow Control. *Machinery (N.Y.), 48,* No. 6, 155 (1942). Porex is used to remove foreign materials from fluids, for controlling flow rates; it can be bonded to steel or copper.

(4271) Ross Filter Foils by Evaporation. J. C. Clark, and R. H. Esling, *Rev. Sci. Instruments, 13,* No. 9, 383-6 (1942). Powdered Sb is evaporated in vacuum to form a deposit on cellophane backing.

(4272) Powdered Metal Process for Molding Parts. H. W. Perry, *Aircraft Engineering, 15,* 305-306 (1943). Small conical metal filters for Diesel engine ejection nozzles are described, and porous sintered iron is mentioned for flame equalizers.

(4273) Porous Metals in Chemical Industry. J. W. Lennox, *Ind. Chemist, 20,* No. 238, 600-604, 615 (1944). Account of physical properties of methods of testing metallic filtering and diffusing alloys made by pressing and sintering of metal powders that are carefully sized.

(4274) Filters Made of Porous Metal Can Be Fabricated in Special Shapes. E. W. Reinsch, *Product Eng., 15,* No. 11, 769-771 (1944). Materials made from tiny metal spheres can now be produced to specified and controlled porosity.

(4275) Porous Metals for Key Functions. W. Kaempfert, *New York Times,* Nov. 25, 1945; *J. Commerce,* Nov. 28, 1945. Manufacture of mercury-permeable porous sintered nickel cup for proximity fuse of U.S. Navy described.

(4276) Call on Powdered Metal Process for Nickel Filters. *Steel, 118,* No. 16, 84-85, 132 (1946). Airflow and porosity tests on a new machine insure uniformity in cup-shaped powdered metal filters for mercury safety switch of V-T fuse. Superfinished dies afford dimensional control.

(4277) Flow of Fluids Through Porous Parts and the Measurement of Specific Surface. P. J. Ridgen, *Nature, 157,* No. 3983, 268 (1946). Using compressed powder plugs having channels of 1 micron, and correcting for slip at the walls, concordant results for the flow of air and liquid were obtained.

(4278) Manual 22: Parts and Metal Forms. *Materials & Methods, 25,* No. 1, 94 (1947). New developments in powder metallurgy during the past year, including use of stainless steel powder to make sintered ductile plates for filters, aeration units, flame arresters, etc.; sintered nickel filters for V-T fuse.

(4279) Pressure Snubbers, an Application of Porous Metals. D. B. Pall, *Instrument Maker, 15,* No. 5, 26-31 (1947); *Powd. Met. Bull., 2,* No. 6, 141-142 (1947). Filter-type snubbers made of porous metals (*e.g.*, stainless steel) are superior to orifice-type snubbers in preventing pressure gage failure due to shocks.

(4280) Powdered Metal Filters. H. Seymour, *Mining Mag., 77,* 206-207 (1947). Porous filters of bronze and stainless steel are made from metal powder by sintering.

(4281) Highly Porous Metal Compounds as Filters. C. E. Sinclair, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Spec. Rept. No. 38, London, 1947, pp. 105-109; *Met. Powd. Rept., 1,* No. 11, 172-173 (1947). Filters are mostly made of atomized 11% Sn bronze particles which are reasonably spherical. Specimens 0.5-0.3 in.^{2} have tensile strength of 1.1-2.1 tsi.

(4282) Flow of Gases Through Porous Metal Compacts. P. Grootenhuis, *Engineering, 167,* No. 4340, 291-2 (1949). Flow characteristics can be determined by measuring pressure drop across specimen at different mass flows; compacts were made by powder metallurgy methods from copper-tin alloys; disks of varying thickness were also tested.

(4283) Porous Metal in Chemical Industry. J. W. Lennox, and G. Brewer, *Ind. Chemist, 25,* No. 288, 31-35 (1949). Metal compacts for infiltration of liquids and experiments with 11% tin bronze compacts are discussed. A spherical particle powder is essential; this is produced by atomizing. Metal filter removed 92% of solids.

C. Wear-resistant products

(4284) Machine Parts from Metal Powder. *Metallwirtschaft, 19,* 958 (1940). A description of the porous, sintered oil pump gears from iron powder is given.

(4285) Hard Iron Parts. F. V. Lenel, *Iron Age, 148,* No. 18, 29-32 (1941). Manufacturing of extremely hard and wear resisting self-lubricating porous iron parts described.

(4286) Iron Oil Pump Gears by Powder Metallurgy. B. H. Dyson, and D. R. Snowden, *Can. Metals Met. Inds., 5,* No. 11, 337-8 (1942). Development in powder metallurgy; physical properties, sintering conditions, and finishing operations are discussed.

(4287) Oil Pump Gears, An Example of Iron Powder Metallurgy. F. V. Lenel, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 45, pp. 502-511. Method suitable for mass production of oil pump gears with 20% porosity and oil-impregnated. Comparison with cast gears and limitations of process.

(4288) Steam Treatment of Porous Iron Articles. F. V. Lenel, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 46, pp. 512-519. Extra rigidity and hardness make steam treated articles suitable for various applications like metal-cutting saws, roller supports, etc.

(4289) Piston Rings. J. A. Judd, *Automobile Engr., 34,* No. 453, 379-80 (1944). Application of powder metallurgy technique by British Piston Ring Co., Ltd. to the manufacture of piston rings. Research work established that high strength properties could be obtained even though the material was considerably less dense than normal cast iron materials.

(4290) Iron Powder for Shell Rotating Bands. *Metal Progress, 47,* No. 4, 705 (1945). War-time substitution of copper bands by porous sintered iron, of low carbon content.

(4291) Sintered Iron Shell Bands. G. M. Butler, U.S. Dept. Comm. P.B. 1834 (1946); *Bibl. Scient. & Ind. Rept., 1,* No. 1, 124 (1946). The production of porous sintered Fe driving bands at Metallwerk Plansee is outlined. *Cf.* C.I.O.S. Rept. No. XXX-8 (1946).

(4292) Manufacture of German High Explosive Shell Steel for Artillery. J. D. Dickerson, C.I.O.S. Rept. No. XXIX-27 (1946). Shell driving bands are covered in one section.

(4293) German Centrifugal Castings Industry. M. M. Hallett, B.I.O.S. Final Rept. No. 700 (1946). Piston rings from D.P.G. powder plus 1% Cu and 0.5-1.5%

colloidal graphite were made by Alfred Teves, Frankfurt, on an experimental scale.

(4294) Sintered Iron and Steel Components. C. J. Leadbeater, B.I.O.S. Final Rept. No. 595, 1946, 61 pp.; *Met. Powd. Rept., 1,* No. 4, 53 (1946). The report covers the manufacture of sintered iron shell driving bands at Metallwerk Plansee, Reutte, and at Vereinigte Deutsche Metallwerke, Neurode. Sintered at equal pressing densities, the compacts gave tensile strengths in the following order of decreasing merit: Vogt (sponge iron powder), Hametag(eddy mill powder), "RZ" (cast iron atomized with moist air), "D" (cast iron atomized with steam), "D.P.G." (rotating disk powder). Best results with Hametag/Vogt mixture.

(4295) Manufacture of Shell Driving Bands Using Iron Powder. A. H. Ross, C.I.O.S. Rept. No. XXVII-10 (1946); *Met. Powd. Rept., 1,* No. 3, 45 (1946). Sintered porous, paraffin-impregnated iron bands produced by Hanomag, Hannover, have certain ballistic advantages over Cu bands, as they give lower barrel wear in many cases. Sintered bullet cores and small components made at Neurode and Reutte.

(4296) Material for Replacement of German Rotating Bands. R. T. Wright, U. S. Dept. Comm. PB. 22827, 11 pp.; *Bibl. Scient. & Ind. Rept., 2,* No. 1, 35 (1946). Covers the results of German replacement of copper rotating bands by various materials including sintered iron, which was found to be the most acceptable substitute.

(4297) Sintered Iron Shell Bands. *Iron & Steel, 20,* No. 8, 370-71 (1947). The production at Hanomag plant, Linden, Germany, is described; powder mixing, annealing and pressing; sintering process; impregnation with lubricant.

(4298) Manufacture of Products from Ferrous Powder Metals. A. G. Haffenden, K. Heywood, R. J. Doyle, C. F. Austin, and R. A. Bellamy, B.I.O.S. Final Rept. No. 908, 1947, 17 pp.; *Met. Powd. Rept., 1,* No. 7, 104 (1947). Describes the pressing and sintering equipment at several German factories which made iron shell driving bands and iron bearings.

(4299) The Production of Powdered Iron and Sintered Iron Driving Bands in Germany. W. Ivory, B.I.O.S. Final Rept. No. 1323, 1947, 120 pp.; *Met. Powd. Rept., 2,* No. 1, 4-6 (1947). The development, manufacture, and testing of sintered iron driving bands is described in detail.

(4300) German Sintered Iron Driving Bands. W. Ivory, *Symposium on Powder Metallurgy.* The Iron and Steel Inst., Special Report No. 38, London, 1947, pp. 203-208; *Met. Powd. Rept., 1,* No. 12, 184 (1947). Story of German sintered iron shell driving bands told by military experts; manufacture and testing are described.

(4301) Sintered Iron Shell Rotating Bands. H. L. Krebs, F.I.A.T. Rept. No. 979 (1947); *Powd. Met. Bull., 3,* No. 2, 42 (1948). A quite brief description of the iron powders used, the procedure for manufacturing driving bands, and their physical properties.

(4302) German Methods of Forging and Machining H.E. & A.P. Shell. F. S. Poulton, and A. George, B.I.O.S. Final Rept. No. 890 (1947). Describes very briefly the manufacture of shell driving bands at Hanomag, Hannover.

(4303) Production of Soft Porous Iron Driving Bands. P. Bardenheuer, F. D. Rept. No. 688/48 (1948) (formerly H.E.C. 13714). A two-page summary of developments from 1917 to 1945.

D. Miscellaneous

(4304) Materials in the Construction of Pipe Lines. K. Beyer, *Arch. Wärmewirtschaft, 18,* 185-8 (1937). Use of porous sintered Fe-powder instead of lead in flange packing.

(4305) Porous Metal Screens. *Wire Ind., 13,* 561 (1946). Sintered porous copper screens as a substitute for wire screens are described.

(4306) Aircraft Liquid De-Icing Equipment. T. K. S. (De-Icing) Ltd., *Symposium on Powder Metallurgy*. The Iron and Steel Inst. Special Rept. No. 38, London, 1947, 110-112; *Met. Powd. Rept., 1*, No. 11, 173 (1947). A de-icing fluid, metered under conditions of utmost precision, is pumped through strips of porous metal inserted in edges of wings of aircraft to prevent the formation of ice.

(4307) Powder Metallurgy of Porous Metals and Alloys Having Controlled Porosity. P. Duwez, and H. E. Martens, *Trans. Am. Inst. Mining Met. Eng., 175*, 848-877 (1948). A method has been developed by means of which porous metals and alloys having controlled permeability can be prepared; it consists of mixing porosity-producing substances with a powder mixture, and sintering at a suitable temperature. Work carried out with stainless steel and Hastelloy-B.

(4308) Preparation and Physical Properties of Porous Nickel. H. Martens, *Calif. Inst. Technol. Progress Rept.*, 1948, 19 pp.; *Nuclear Sci. Abs., 2*, 209 (1949). Two kinds of Ni powder, having slightly different particle size, were investigated. The porous specimens were made by pressing and sintering in pure H_2 at 1200° C. (2200° F.). The porosity after sintering varied from 7 to 45%, depending on the metal powder, the amount of ammonium bicarbonate, and the pressure.

(4309) German Developments of Porous Materials for Transpiration Cooling. F. Meyer-Hartwig, *U. S. Air Forces, Air Materiel Command, Air Documents Div., Dayton, Ohio, Doc. U 2138*, Sept. 1948. Early German development work in 1940 on transpiration-cooling of materials for rocket nozzles is reported.

(4310) Metallurgical Aspects in Design of Rocket Motors. J. N. Nutt, *Am. Rocket Soc., No. 73*, 31-33 (1948). Ceramic materials and porous metals offer good possibility for rocket motors. Al and Mg are almost useless.

(4311) Porous Metal De-Icer Panels. *Aircraft Prod., 11*, 424-25 (1949). Porous metal strip 3/32 in. thick is used for covering the leading edges of aircraft wings, instead of the in-laid bar type, used during the war. Atomized phosphor bronze is used to avoid electrolytic action.

(4312) Powder Metallurgy and the Gas Turbine. P. Grootenhuis, and N. P. W. Moore, *Engineer, 187*, 502 (1949). In connection with the article by H. W. Greenwood in *Engineer, 187*, 349 (1949) the authors write that theoretical and experimental work on sweat-cooling has been in progress for some years at City and Guilds College, London.

(4313) Sweat Cooling. E. A. Richardson, and G. A. Richardson, *J. Metals, 1*, Sec. 1, 13-14 (1949). A communication to the paper of P. Duwez and H. E. Martens before the Institute of Metals Division at New York, Feb. 1948.

8. FRICTION PRODUCTS
(clutch facings, brake linings)

(4314) Brake Linings. H. E. Blank, *Automotive Ind., 79*, No. 12, 346 (1938). Clutch facings from metal powders mixed with small amount of a non-metallic material are described.

(4315) Friction Materials from Powdered Metals. *Metals & Alloys, 13*, No. 6, 753 (1941). "Velvetouch" commercial notice by S.K. Wellman Co.

(4316) Sintered Metals in Friction Devices. E. F. Cone, *Metals & Alloys, 14*, No. 6, 843-50 (1941). Description with pictures, "Velvetouch" clutch parts manufactured by the S. K. Wellman Co.

(4317) Powdered Metal Facings for Clutches and Brakes. M. S. Adler, R. B. Aufmuth, and F. J. Lowey, *Product. Eng., 14*, No. 4, 218-21 (1943). Consideration in design or use of bimetallic clutch and brake elements discussed.

(4318) Metal Powder Friction Materials. J. F. Kuzmick, *A. S. T. M. Symposium on Powder Metallurgy*, Philadelphia, Pa., 1943, pp. 44-48. Characteristics

described in friction material; ingredients used include Cu, Sn, Fe, Pb, graphite; pressing and sintering procedure; discussion by E.T. Larkin, M.R. Hatfield.

(4319) **Powder Metallurgy.** W. D. Jones, *Aircraft Prod., 6,* No. 67, 226-229 (1944). Clutches for airplanes have a lining of 50-60% Cu, 5-10% Sn, 5-10% Fe, 5-15% Pb, plus 2-7% fine SiO_2.

(4320) **Metal Powder Friction Materials.** C. S. Batchelor, *Metals & Alloys, 21,* No. 4, 991-93 (1945). Method of fabricating sintered metallic friction articles; history, producers, materials, war-time achievements, future.

(4321) **Friction Articles from Metal Powders.** C. T. Cox, *Trans. Am. Inst. Mining Met. Engrs., 161,* 565-568 (1945). Limitations, obtaining adequate strength, selection of mixture, effect of variations in composition, field of usefulness discussed by W. A. Reich.

(4322) **Clutch Facings and Brake Linings of Powdered Metal Type.** J. Geschelin, *Automotive and Aviation Inds., 92,* No. 7, 24-6, 85-6 (1945). Illustrated description of methods employed in production of facings at S. K. Wellman Co.

(4323) **Powder Metallurgy.** F. C. Kelley, *Metals Rev., 19,* No. 6, 6 (1946). In a talk before the Buffalo Chapter of the American Society for Metals in April, 1946, it was stated that brake drums from metal powders are successfully produced by a large automobile manufacturer.

(4324) **Brake Linings from Metal Powders.** G. Wassermann, and Metallgesellschaft A. G., F.D. Rept. No. 1076/46, 1946, 10 pp.; *Met. Powd. Rept., 1,* No. 5, 74 (1947). The most promising results were obtained with 25% Mg powder, 40% Kieselguhr, 35% resin. Report dated 1938.

(4325) **Powdered Metal Friction Material.** F. J. Lowey, *Mech. Eng;, 70,* 869-71 (1948). Friction material is of bimetallic nature, in which the sintered powdered material is supported by a core or backing plate of low carbon steel, sometimes bronze. The sintering is carried out under pressure of 100-200 psi, at a temperature 675-900° C. (1250-1650° F.). The friction material is of great wear resistance and can absorb higher rates of energy than organic material.

9. DENTAL ALLOYS

(4326) A. Wetzel, *Füllen der Zähne mit Amalgamen.* Berlin, 1899. A description is given of the filling of dental cavities with amalgams of copper, gold, silver, tin, and their alloys.

(4327) G. V. Black, *The Conserving Dentistry.* Shephard, Chicago, 1913, Vol. II. The consumption of powdered gold, silver, copper, tin, and their alloys in dental amalgams used for fillings of tooth cavities is discussed.

(4328) **Amalgams Containing Silver and Tin.** W. A. Knight, and R. A. Joyner, *J. Chem. Soc. Trans., 103,* 2247-62 (1913). The equilibrium conditions in the silver-tin-mercury system are treated.

(4329) **Metallographic Phenomena Observed in Amalgams.** A. W. Gray, *Trans. Am. Inst. Mining Met. Engrs., 60,* 657-97 (1919). The mercury content in dental amalgams is investigated, and it is found that in the technical alloys the amount of Hg remaining in the amalgam after squeezing is inversely proportional to the logarithm of the exerted pressure.

(4330) C. S. Gibson, *Chemistry of Dental Materials,* Benn Brothers, London, 1922, 176 pp. Chemistry of amalgams of copper and precious metals is treated; effect of gases such as H_2 or NH_3 on gold powder is described.

(4331) **Volume Changes Accompanying Solution and Crystallization in Amalgams.** A. W. Gray, *J. Inst. Metals, 29,* 139-89 (1923). A study of the volume changes in dental amalgams revealed that several expansion and contraction cycles may occur over periods of many days.

(4332) **Silver-Tin Amalgams.** G. Tammann, and O. Dahl, *Z. anorg. allgem. Chem., 144,* 16-20 (1925). Investigation of the absorption of Hg in Ag-Sn prealloys.

(4333) **Silver-Tin Alloys and Amalgams.** O. Loebich, and L. Nowack, *Deut. zahnärztl. Wochschr., 31,* 843-44 (1928); *Metallwirtschaft, 8,* 654-55 (1929). The effect of the history, and composition of the silver-tin prealloy on the properties of the amalgams is shown.

(4334) **Investigations of Tin-Silver Amalgams.** E. Wannenmacher, *Deut. zahnärztl. Wochenschr., 32,* No. 8, 367-371 (1929). The relation between the mercury and silver contents and the prealloy content in dental amalgams is discussed.

(4335) L. Speier-Pinkus, *Rezeptarium für Zahnheilkunde und Zahntechnik,* Deutistischer Verlag, Berlin, 1930. A description is given of the use of silver, tin, copper and gold powders in the preparation of amalgams for dental fillings.

(4336) L. Sterner-Rainer, *Edelmetallegierungen und Amalgame in der Zahnheilkunde.* Meusser, Berlin, 1930. Reference is made to the production and uses of noble metal alloys and amalgams in dentistry.

(4337) **Quick-Hardening Amalgams.** O. Loebich, *Zahnärztl. Rundschau, 42,* No. 19, 879-882 (1933). The effect of time on the uniform hardening and diffusion processes in dental amalgams is shown.

(4338) **Constitution of Alloys of Silver, Tin and Mercury.** M. L. V. Gayler, *J. Inst. Metals, 60,* 379-97 (1937). The equilibrium condition in silver-tin amalgams is investigated.

(4339) E. A. Smith, *A Manual on Dental Metallurgy.* 5th Ed., J. and A. Churchill, Ltd., London, 1937, 320 pp. The effect of hydrogen and ammonia gases on gold powder is discussed.

(4340) **X-Ray Study of Dental Amalgams.** A. R. Troiano, *J. Inst. Metals, 63,* 247-59 (1938). The silver-tin-mercury system was investigated and the equilibrium conditions are described.

(4341) **Tin and Its Alloys in Dental Practice.** F. C. Thompson, and N. Wild, *Pubs. Internatl. Tin Research Development Council,* No. 89 (1939). A description of silver-tin amalgams for dental fillings is given. The silver-tin prealloy common in the U. S. analyzes 67.7% Ag, 26.3% Sn, 4.7% Cu, and 1.2% Zn.

(4342) **Properties of Dental Amalgams.** O. Loebich, and L. Nowack, *Z. Metallkunde, 32,* 15-18 (1940). The properties of dental amalgams are shown as a function of the composition and treatment of the silver-tin pre-alloy.

(4343) E. Raub, *Die Edelmetalle und ihre Legierungen.* Springer, Berlin, 1940. On pp. 160 ff, a history of amalgams is given and it is shown that amalgamation belongs to the oldest applications of powder metallurgy.

(4344) **Research into Dental Amalgams at R.A.F. Inst. Aviation Medicine.** W. Harvey, *Brit. Dental J., 81,* 245-46 (1946); *Chem. Abstr., 41,* No. 8, 1975 (1947). Of amalgams of 84 alloys only one half conform to the standards set by the American Dental Assoc.

(4345) E. W. Skinner. *The Science of Dental Materials.* 3rd ed., W. B. Sounders Co., Philadelphia, 1946. Amalgams (*e.g.*, of copper and silver-tin, or gold) are treated (in particular on pp. 316 ff.).

(4346) **Amalgams and Sintered Metals with Diamonds and Metal Oxides.** W. Hennig, *Einführung in die Pulvermetallurgie.* Technische Hochschule, Graz, 1949, pp. 185-96. Production of amalgams for dental purposes is described.

10. MISCELLANEOUS APPLICATIONS FOR METAL POWDERS

A. Sintered products (jewelry, medals and coins; laminated, composite and bimetallic products; miscellaneous products)

(4347) Production of Impressions on Medallions. G. Osann, *Ann. Phys. Chem., 128,* 406-421 (1841). Compression of Cu powder which is spread out on the coin, followed by annealing of the product, is described.

(4348) Bearings from Metal Powder – A New Art. E. Fetz, *Metals & Alloys, 8,* No. 9, 257-60 (1937). Suitable for composite bearings, consisting of Cu-Pb layers attached to steel backing.

(4349) Powder Metallurgy Applied to the Manufacture of Cu-Pb Bearings. *Metallurgia, 18,* No. 103, 40 (1938). Favorable results by powder process were achieved by sintering in H a pressed strip consisting of Cu powder layer at the bottom and a Cu-coated lead powder at the top.

(4350) Powdered Metal Coins. *Science, 88,* No. 2284, Suppl. 12 (1938). Reference is made to talk by G. J. Comstock at meeting of Am. Soc. Mech. Engrs. in Providence, R. I., on Oct. 7, 1938. Coinage alloys that include a precious metal require an extremely exact control of composition, which raises the cost of production by melting. Alloyable mixtures of metal powders could be coined to a high density without scrap losses.

(4351) Bearings. C. F. Smart, *Metal Progress, 36,* No. 4, 349-50 (1939). Deals partly with manufacture of composite, babbitt-lined, steel-backed bearings by powder metallurgical means.

(4352) Steel Back Babbitt Bearing for Buick Engines. *Automotive Ind., 83,* 160-2 (1940). Matrix for bearing consists of a mixture of pure Cu and Ni powders.

(4353) Powdered Metals In Composite Bearings. *Steel, 107,* No. 6, 46-47, 78 (1940). Production of a new type of steel-backed, high-lead babbitt precision bearing, which will increase the life of an engine bearing by over 200%.

(4354) Sintered Powdered Metals Help Make High Grade Bearings. C. M. Heath, *Steel, 107,* No. 16, 162-163 (1940). Bearings of Cu-Ni powder sponge sintered to steel back and impregnated with a lead-rich alloy.

(4355) Powder Metallurgy Brings New Bearing Properties. R. P. Koehring, *Inco, 17,* No. 3, 18-20 (1940). New bearing "Durex 100" developed by General Motors Corp.; thin layer of high-lead babbitt bonded to steel back by means of intermediate layer of Ni-Cu.

(4356) Powdered Metal Compacts Bond Babbitt to Steel. R. P. Koehring, *Metal Progress, 38,* No. 2, 173-6, 196 (1940). A strong but porous "matrix" consisting of 60% Cu and 40% Ni powder, sintered into the steel back, affords a rough and chemically reactive surface with which the actual bearing metal coalesces and interlocks.

(4357) Bearings by Powder Metallurgy. *Can. Metals Met. Inds., 4,* No. 6, 147-48 (1941). Babbitt bearings by General Motors Corp. The sintered matrix of Cu and Ni powder, controlled in its porosity, is firmly bonded to the steel backing.

(4358) Bearings with Improved Properties; A Development of Powder Metallurgy. *Chem. Age (London), 44,* No. 1140, 256 (1941). Research indicates that it is possible to bond an extremely thin layer of babbitt securely to a steel backing.

(4359) Investigation of Electrolytically Produced Laminated Iron-Nickel Sheets. K. Heck, *Wissenschaftl. Veröffentl. Siemenswerke, 20,* No. 1, 104-34 (1941). A process of producing iron-nickel bimetal strips is described, whereby the two metals are alternately electrodeposited in layers of a few microns thickness and thereafter are diffusion alloyed during annealing.

(4360) Engine Bearings Manufactured by Powder Metallurgy Process. R. P. Koehring, *Diesel Power, 19,* No. 9, 772-774 (1941). A porous matrix is formed by heating a mixture of 40% Ni and 60% Cu in controlled atmosphere, to sinter the powders and to bond them to the steel backing strip.

(4361) Copper-Nickel-Lead Bearings. A. L. Boegehold, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 47, pp. 520-9 (1942). Micropictures of different alloys used for lining composite steel-backed heavy duty bearings.

(4362) Copper-Lead Bearings by Powder Metallurgy. W. D. Jones, *Metallurgia, 28,* No. 168, 255-60 (1943). Composite copper-lead bearings bonded on steel backing by technique of powder metallurgy are described.

(4363) Auto Bearing by Powder Metallurgy. *Materials & Methods, 22,* No. 5, 1551 (1945). "Durex 100" engine bearing produced by Moraine Products Div., General Motors Corp., is described. Product is essentially a composite steel-backed lead-base babbitt-lined bearing, with an additional intermediate layer of a metallic sponge-like structure copper brazed to the steel back into which the babbitt is cast.

(4364) New Products in Review. *Metals Rev., 18,* No. 12, 18 (1945). Composite engine bearings "Durex 100" made by Moraine Products Div., General Motors Corp., are described.

(4365) Bearing Materials and Design. E. R. Darby, *Metals & Alloys, 21,* No. 1, 108 (1945). Part of "Materials for Solving Specific Engineering-Service Problems", a group of articles. Copper-lead lined steel back composite bearings made by powder metallurgy cited as recent development.

(4366) Sintered Powder Metal Composites May Be Fit for Specialized Needs. *Elec. Mfg., 38,* No. 4, 132 (1946). Porosity makes them valuable for bearings, and ease of producing complex forms of various materials without machining renders them suitable for a variety of engineering applications.

(4367) New Developments in Bearing Metals. O. W. Ellis, *Can. Mining Met. Bull., 39,* 447-50 (1946). Cu-Pb alloys; Cd base alloys; Cu-Ni alloys; bimetallic bearings by casting and sintering.

(4368) Precision Powder Spreader and Other Highlights of Bearing Strip Process. *Automotive Inds., 97,* No. 10, 46, 78, 82 (1947). Procedures and equipment for production of copper-lead sintered bearings at Greenville plant of Federal-Mogul Corp. Unique device for spreading Cu powder over steel strips in order to produce a parallel top surface and uniformity of layer thickness.

(4369) Copper-Lead Bearings from Metal Powder. E. R. Darby, *Proc. Third Ann. Spring Meeting,* Metal Powder Assoc., New York. May 27, 1947, pp. 52-56. Steel back Cu-Pb composite bearings proved value under heavy service conditions. Method used by Federal-Mogul Corp. in making bearings is much less troublesome than methods involving casting. Discussion.

(4370) Production of Lead-Cored Wire. R. Delaplace, *Compt. rend., 225,* No. 22, 1075-77 (1947). A lead core is sprayed by a wire gun with Cu powder, produced of the molten metal; the product is annealed at 290° C. (550° F.) then pressed and sintered in reducing atmosphere.

(4371) Powder Metallurgy in Plastic Cavity Mold Manufacturing. O. Pritchard, *Ind. Gas, 27,* 7-8 (1947). Powder metallurgy for mass production of molds having complex designs and patterns.

(4372) Bearings. W. E. Thill, *S. A. E. Journal, 55,* No. 7, 66-67 (1947). Comparison of tubing method with the powder metal composite strip process for production of bearings; tin-base and high lead bearings can be made by either method. Advantages of powder metallurgy are the blending of the powder mixture prior to the application; it produces a uniform product, conducive to a good bearing performance

(4373) Die-Casting Dies. H. K. Barton, *Metal Ind. (N.Y.), 73,* No. 18, 353-54 (1948). Data on process for the reproduction of cavity inserts by powder metallurgy, and new development in die construction technique; sintered metal powders pressings in die forming process.

(4374) From Research to Production: Development of Copper-Lead Sintered Bearings. W. H. Tait, *Metal Ind. (N.Y.), 72,* No. 26, 521-23 (1948). Illustrated by the development of a bearing material with the good properties of white material

and the fatigue strength of cast Cu-Pb. Bearings are steel-backed composites.

(4375) Designing for Production of Parts by Powder Metallurgy. J. L. Bonanno, *Steel, 125,* No. 8, 68-70, 72, 74, 77 (1949). Includes a description of the production of laminated structures.

(4376) Sintered Bearings. H. W. Greenwood, *Machinery Lloyd, 21,* No. 18, 103-5 (1949). Composite copper-lead is used for bearings in Diesel engines, tractors, and transport vehicles. Production of steel-backed bronze-lined oil-retaining bearings.

(4377) Moraine Durex-100 Engine Bearings. J. A. Lignian, *Trans. Am. Soc. Metals, 42,* 124-30, 136-37 (1949). The bearing is steel-backed, lead-base, babbitt-lined, in which the surface is supported by a spongy metallic base; a mixture of Cu-Ni powders is sintered to the base.

(4378) Metal Powder and Hard Particles Made into Steel-Backed Bearings. H. L. Strauss, Jr., *Metal Progress, 56,* 359 (1949). Bearings for high temperature and extreme speeds are made by hot-pressing a combination of metal powders, carbides or borides upon a cylindrical copper-plated steel die which is then machined.

B. Molded products (metal combinations with plastics, including coatings)

(4379) Metal Powders and Organic Plastic Binders. J. Delmonte, *Modern Plastics, 16,* No. 9, 49-50, 74, 76, 78 (1939). The uses of metal powders bonded with various synthetic resins as magnetic cores, motor brushes, and bearings are discussed. 23 references.

(4380) Mixture of Bakelite and Metal Powder for Mounting Micro Specimens. N. J. Finsterwalder, *Metal Progress, 38,* No. 3, 294 (1940). Copper and aluminum powders have proved to be most satisfactory for this application.

(4381) Production and Properties of Pressed Permanent Magnets. H. Dehler, *Z. Elektrotechnik, 62,* No. 27, 601-06 (1941). Discussion includes powdered magnetic material and resin binder.

(4382) Plastics and Powder Metallurgy. H. W. Greenwood, *Plastics (London), 5,* 215-16 (1941). Applications of powder metal - plastics combinations in the decorative and electrical fields are discussed.

(4383) Compressed Powder Magnets with Synthetic Resin Binder. H. Dehler, *J. Roy. Aeronaut. Soc., 47,* No. 387, 86 (1943); Abstracts from *Stahl u. Eisen, 62,* No. 47, 983-6 (1942). Magnetic qualities of compacted magnets produced with resin binder (6%) are within 20% of corresponding values for cast material.

(4384) Metallizing Plastics. E. E. Halls, *Plastics (London), 7,* No. 73, 235-43; No. 74, 281-6; No. 75, 337-48; No. 78, 486-95, 507; No. 79, 549-61 (1943). (*I*) Films applied by means of metal powders in varnish or lacquer medium. (*II*) Electrically conducting films applied by means of metal powder in varnish or lacquer medium. (*III*) Metal coatings applied from metal wire, powder or liquid using "hot pistols."

(4385) Efficiency and Economy of Compressed Powder Magnets with Synthetic Resin Binders. H. Dehler, *Elektrotech. Z., 65,* No. 11/12, 93-5 (1944). Advantages compared with cast permanent magnets. Material discussed is powdered Al-Ni-Fe with resin binder.

(4386) Plastic Bonding of Boron Powder. L. Hays, and J. E. Burke, *U. S. Atomic Energy Comm., 2279,* 1944, 2 pp. Wet tamping boron powder with methyl methacrylate monomer and polymerizing to produce a piece with 1.6 g./cc. density.

(4387) Electropolishing of Microspecimens. U. J. Hochschild, *Metals & Alloys, 21,* No. 2, 409-12 (1945). Supplementing paper on plastic mounting powders by same author in *Metals & Alloys, 20,* No. 6, 1614 (1944). Method described for mounting small specimens that combines powder metallurgy and plastic molding.

(4388) Plastics Increase Powder Metal Flow. H. L. Strauss, Jr., *Am. Machinist, 89,* No. 20, 113 (1945). 5% vinyl resin by volume is added to powdered metal in briquetting die to improve flow.

(4389) Producing Frangible Plastic Bullets. L. E. Welch, *Iron Age, 155,* No. 21, 51-52, 128-30 (1945). 0.30 caliber molded plastic bullets from lead powder with resin binder for purposes of training aircraft gunners.

(4390) Permanent Magnets. S. Harris, *Plastics (London), 10,* 534 (1946). Plastic-bonded permanent magnet alloy granules are described.

(4391) Plastics Increase Powder Metal Flow. H. L. Strauss, Jr., *Machinist (London), 89,* No. 42, 2275 (1946). Information on use of up to 5% vinyl resin with metal powders is given.

(4392) J. R. I. Hepburn, *Metallization of Plastics.* Cleaver-Hume Press, London, 1947. Metal powders are mentioned under headings of bronze and metal spraying.

(4393) Polyvinyl Acetate in Powder Metallurgy. H. L. Strauss, Jr., *Modern Plastics, 24,* 196, 198 (1947). The plastic component is suggested as a pore-creating agent or a pressing lubricant; it becomes viscous at 65° C. (150° F.) and is entirely eliminated from the compact at temperatures above 400° C. (750° F.) with practically no carbon residue deposited at the pore walls.

(4394) Plastics, Rubber Moldings and Metal Parts Combined to Advantage. H. Chase, *Materials & Methods, 27,* No. 3, 67 (1948). Combinations of conducting and dielectric properties are provided in electrical parts by judicious use of molded sections containing metallic inserts.

(4395) Metallic Vinyls Make Good. *Modern Plastics, 26,* No. 6, 66-67 (1949). 1% Al flake powder is incorporated as a paste in vinyl resin mixes.

C. Applications for metallurgical industries (welding electrodes and agents; brazes, solders, seals; alloy cutting agents; master alloys; melting charges and alloying or addition elements; magnetic testing)

(4396) Welding Powder with Aluminum Content. *Z. Ges. Giessereipraxis, 47,* 166 (1926). Application of welding flux powder with Al content for welding of cast iron.

(4397) Acid-Proof Alloys with Nickel Bases. W. Rohn, *Z. Metallkunde, 18,* 387-96 (1926). A series of nickel-chromium alloys containing from 2 to 10% tungsten have been developed under the name of Contracid. Their valuable properties make them very useful, especially in acid-resisting applications.

(4398) Expansion Characteristics of Low-Expansion Nickel Steels. H. Scott, *Trans. Am. Soc. Steel Treatment, 13,* 829-47 (1928). A ternary, low-expansion alloy of iron, nickel, and cobalt ("Fernico" or "Kovar") is described. This alloy is particularly suitable for glass-to-metal seals.

(4399) Influence of Sponge Iron on the Properties of Steel. W. Rohland, *Stahl u. Eisen, 49,* 1477 (1929). Benefits from use of sponge Fe in charge. Investigation of testing melts. Importance of the qualitative influence of sponge iron.

(4400) Magnetic Powder Inspects Turbine Blading. F. C. Jacobs, *Power, 77,* 238-9 (1933). Process involving iron powder as testing medium described.

(4401) Expansion Properties of Low-Expansion Fe-Ni-Co Alloys. H. Scott, *Trans. Am. Inst. Mining Met. Engrs., 89,* 506-37 (1930). A ternary alloy of iron, nickel, and cobalt of especially low coefficient of expansion ("Fernico" or "Kovar") is described. This alloy is particularly suitable for sealing certain types of glasses to metals.

(4402) Zinc-Dust Consumption of Canadian Gold Mines. A. Busson, *Mining Congr. J., 20,* No. 7, 21-2 (1934). Methods of precipitating Ag. Production and costs of Zn dust.

(4403) Glass-to-Metal Seals. A. W. Hull, and E. E. Burger, *Physics, 5,* 384-405 (1934). Ternary alloys of iron, nickel and cobalt containing 28-30% Ni, 15-19% Co, balance Fe, excel by their very low coefficient of expansion, making them ideal glass-sealing materials.

(4404) Melting Zinc Dust under Fluxes. N. N. Murach, and G. K. Markarov, *Tsvetnye Metal.,* No. 2, 107-108 (1934). Coarse fractions of Zn powder remaining after sieving are not reloaded into distillation retorts because of their bulkiness. Rapid oxidation of Zn was serious difficulty in remelting. Oxidized particles do not form liquid even when placed in liquid Zn, and use of flux was necessary.

(4405) Recent Developments in Metal Sealing into Glass. H. Scott, *J. Franklin Inst., 220,* 733-753 (1935). *Cf. Trans. Am. Inst. Mining Met. Engrs., 89,* 506-37 (1930).

(4406) Alloy for Sealing into Glass. H. Scott, *Mining and Met., 16,* 229-230 (1935). Co substituted for part of the Ni is shown to improve the expansion properties of Fe-Ni alloys for glass sealing.

(4407) W. Espe, and M. Knoll, *Werkstoffkunde der Hochvakuumtechnik.* Springer, Berlin, 1936. On pp. 226 ff. a detailed discussion of the metal-to-glass sealing properties of iron-nickel-cobalt alloys is given.

(4408) Sinterit. H. Vogt, *Gesundh. Ing., 59,* 628-30 (1936). Describes a new material for sealing consisting of iron particles mixed with bitumen, called "Sinterit."

(4409) Powdered Zinc and Cadmium for X-Ray Scattering. W. A. Bruce, *Rev. Sci. Instruments, 8,* 451 (1937). In order to obtain Debye-Scherrer photographs it is necessary to have undistorted crystals of a size smaller than 10^{-4} cm. Author found a method of producing such crystals for x-ray diffraction experiments.

(4410) The Alloy "Kovar." W. Hessenbruch, *Z. Metallkunde, 29,* No. 4, 193-95 (1937). The coefficient of expansion is given in graphical form for different Fe-Ni-Co alloys. A ternary alloy,known as "Kovar" (also as "Fernico"), having an especially low coefficient of expansion, is described.

(4411) Sinterit. H. Vogt, *Forschungen u. Fortschr., 13,* 119-120 (1937). A new sealing material, called "Sinterit" and consisting of iron particles mixed with bitumen, is described.

(4412) Recovering of Zinc from Zinc Dust by Smelting. *Metall u. Erz, 35,* 317-21 (1938) Thede method described.

(4413) The Hydride Process. II. P. P. Alexander, *Metals & Alloys, 9,* No. 2, 45-48 (1938). Production and properties of titanium and Ti hydride; production of Cu-Ti alloys; Cu-Ti alloys produced by mixing 72% Cu and 28% TiH powders, and heating in vacuum to fusion temperature of the eutectic alloy, 878° C. (1612° F.), whereby Cu is fully reduced.

(4414) Welding of Thin Light Metal Sheets. K. G. Gabler, *Z. Ver. deut. Ing., 82,* No. 49, 1399-1400 (1938). With welding electrodes containing TiC, very good welding on aluminum or Cr-Ni steel is obtained.

(4415) The Metallurgical Aspects of Resistance Welding Electrodes. R. H. Harrington, *Welding J., 17,* 18-22 (1938). Metal powders used in welding rods.

(4416) Sealing Material. W. P. Machajew, *Water Supply Sanit. Technol. (U. S. S. R.), 15,* 36-40 (1938). A new sealing material based on porous sintered iron is described. The iron powder is obtained from iron sulfate by reduction.

(4417) Small Scale Manufacture of Iron and Steel in India by the Direct Method. P. N. Mathur, *Trans. Mining Geol. Met. Inst. India, 34,* 283-303 (1938). Sponge Fe-flow sheets and analysis given.

(4418) Sinterit. F. Milkowski, *Gas- u. Wasserfach, 81,* 236-240 (1938). The applications of this new sealing material are described. Its good sealing properties are attributed to the plastic nature of the porous sintered iron.

(4419) A New Soldering Tool. A. Schaaf, and H. Vatter, *Funk, 14,* 389-90 (1938); *Veröffentlich. Nachrichtentechn., 8,* No. 2, 303-4 (1938). Metal powders used. The soldering point of copper coated with porous sintered iron remains free from scale.

(4420) Recovery of Zinc from Zinc Dust by Melting, Especially by the Thede Methods. J. J. Thede, *Metall u. Erz, 35,* 317-21 (1938). Zn dust is heated above the melting point of Zn in a rotating sealed furnace. The loss of Zn does not exceed 1.5%.

(4421) Powder Braze. *Metals & Alloys, 10,* No. 12, MA 735 (1939). A recently developed low-melting point alloy powder which is especially suitable for joining non-ferrous metals and alloys.

(4422) The Use of CarbonylNickel Powder in Smelting Industries of the German Metal Industry. P. Assmann. and L. Schlecht, *Metallwirtschaft, 18,* No. 22, 467-68 (1939). Nickel powder of high purity is used as starting material for this purpose.

(4423) The Principles of the Glass-Metal Sealing Technique. W. Espe, *Feinmechanik u. Präzision, 47,* 225-30, 247-50, 257-64 (1939). An investigation is made of the principles of vacuum sealing, and it is concluded that a strict conformity of the coefficient of expansion of metal and glass is not necessary. Various sealing alloys are described, including the low-expansion refractory metals (*e.g.*, molybdenum).

(4424) Synthetic Materials with Special Metallic Properties. R. Hanke, *Chem. Ztg., 63,* 80 (1939). Ferromagnetic metal powders are added to increase density in molten material.

(4425) Copper-Zirconium-Cadmium Bronze. F. R. Hensel, E. I. Larsen, and A. S. Doty, *Metals & Alloys, 10,* No. 12, 372-80 (1939). "Hydrinet" zirconium-hydride hardener used in manufacture of the cast copper alloy.

(4426) Problems of Swedish Steel Production. S. V. Hofsten, *Jernkontorets Ann., 123,* 353-85 (1939). Discussion of Swedish Steel, use of sponge Fe in steel making.

(4427) Heat Treatment of Cast Iron with a Thermite Mixture in the Ladle. *Liteinoe Delo, 8-9,* 8-10 (1940) (in Russian). Thermite mixture is added in powder form.

(4428) Preparation of High-Purity Iron on a Large Laboratory Scale. F. Adcock, *J. Soc. Chem. Ind., 59,* 28-31 (1940). Electrolytic iron converted to $FeCl_2$, this to oxide which is reduced and sintered. Iron then melted in hydrogen at reduced pressure. Product 99.994% plus pure.

(4429) The Use of Carbonyl Nickel Powder in Melting Processes by the German Iron and Steel Industry. P. Assmann, and L. Schlecht, *Stahl u. Eisen, 60,* No. 11, 226-27 (1940); *Engrs. Digest, 1,* No. 7, 260-61 (1940). Nickel carbonyl powder has been used satisfactorily instead of solid nickel as a melting charge in acid, open-hearth, basic electric, and induction melting operations for the production of corrosion- and wear-resisting steels, cast irons, and non-ferrous alloys.

(4430) Sponge Iron as Against Pig Iron. M. Tigerschiöld, *Ing. Vetenskaps Akad., 136,* 44 (1940); *Chem. Abstr., 35,* 7337 (1940). Review of its applicability as charge for steel making metallurgy.

(4431) Powder Metallurgists Debate Techniques. *Iron Age, 148,* No. 18, 29-35, 100 (1941). At the Powder Metallurgy Conference at M. I. T., J. Kurtz reported the development of a substitute for Ni wires used in glass-to-metal seals in radio tubes: 200 mesh powder mixtures containing 5-20% Mo and 1% Cu, balance electrolytic iron are compressed and sintered at 1200° C. (2190° F.) for 1 hour in H and then worked into the desired shape.

(4432) Powder Improves Radiographs. L. D. Jennings, *Am. Machinist, 85,* 553 (1941). By filling metal powder around the subjects to permit x-ray examination of the entire area of the subject without blurring the outer edges of the picture.

(4433) The Influence of Non-Magnetic Coatings on the Sensitivity of the Magnetic Powder Testing Method. A. V. Shigaldo, and T. I. Kanaturova, *Zavodskaya Lab., 10,* 320-1 (1941). Coatings of lacquer reduce the sensitivity of testing with magnetic powders so that small defects cannot be detected.

(4434) Precipitation Hardening in the Fe-W System. C. S. Smith, *J. Applied Phys., 12,* No. 11, 817-22 (1941). The alloy contained 7.16% W and was prepared by melting pure Fe and W powders together.

(4435) Iron-Molybdenum Alloys. J. Kurtz, *Powder Metallurgy,* Am. Soc. Metals, Cleveland, 1942, Chapt. 44, pp. 497-501. Iron alloys containing 5, 10, 15 and 20% Mo, and 1% Cu were investigated. Alloys containing 10% Mo used for metal-to-glass seals. Fe-Mo alloys to replace Ni and Ni-alloys in radio tube industries.

(4436) Welding. E. Thiemer, *Techn. Zentralblatt prakt. Metallbearb., 52,* 36-39, 58-61, 83-85, 103-104 (1942). In the welding industry, large quantities of tungs tungsten rod are used as electrodes in arc-atomic welding.

(4437) Magnetic Powders for Testing. R. Berthold, *Z. Ver. deut. Ing., 87,* 399-401 (1943). For non-destructive testing of materials, magnetic powder is used. Small grain size suitable for the detection of surface defects, coarser powder for defects in greater depths.

(4438) Powdered Brazing Alloys for Tipping Tools. *Ind. Heating, 11,* No. 11, 1931 (1944). Two Ag-Cu and one Cu-brazing alloy used for tipping tungsten carbide and high-speed steel tools now available in fine powder form. Products of Eutectic Welding Alloys Co.

(4439) Sponge Iron for Steel Making. *Iron Age, 154,* No. 13, 39 (1944). Item about Brassert-built Republic Steel Corp. sponge iron plant at Warren, O., will go into production.

(4440) Magnetic Powder Inspection of Large Castings. J. F. Cotton, *Trans. Am. Foundrymen's Assoc., 52,* 205-228 (1944). Shows that a standardized technique must be established before standards of magnetic powder inspection can be prepared.

(4441) Sponge Iron. W. A. Janssen, *Steel, 114,* No. 21, 94-5 (1944). Its use will be a must in making special grades of carbon and alloy steels since the dilution of scrap with alloying elements makes it necessary for steel producers to use more virgin material.

(4442) Martensite Formation of Iron-Nickel-Cobalt Alloys. K. Schichtel, and U. Wilke-Dörfurt, *Z. Metallkunde, 36,* 147-48 (1944). The metallography of the Fernico-type sealing alloys is described.

(4443) Powder Brazing Alloys for Tipping Tools. *Iron Age, 155,* No. 3, 56 (1945). Alloys (Ag and Cu) in powder form used for tipping W-carbide and high speed steel tools. Made by Eutectic Welding Alloys Co.

(4444) Brazing Low-Alloy Tool Tips with Powdered Alloys. *Iron Age, 155,* No. 6, 61 (1945). Results of tests by N. A. Bukhman and Yu. A. Geller as published in *Vestnik Metallopromyshlennosti,* No. 8-9, pp. 45-57 (1945). Best results obtained from ferro-manganese brazing alloy containing 20-25% Cu.

(4445) Powdered Metal Welding Rods. *Steel, 117,* No. 24, 130, 133 (1945). Various steps in the production of synthetic welding rods and electrodes by powder metallurgy described; compacting metal powders around iron wire core involved.

(4446) New Methods of Tipping Tools. *Western Metals, 3,* No. 2, 16 (1945). Two outstanding Ag-Cu and one Cu alloy used for tipping W-carbide and high-speed steel tools now available in a fine powder.

(4447) Alloy Welding Wire from Powder Metallurgy. F. G. Daveler, and P. H. Aspen, *Welding J., 24,* No. 9, 842-44 (1945). Information concerning development and production of alloy rods of any desired composition by powder metallurgy process and extrusion.

(4448) Magnetic Particles Inspection. W. E. Thomas, *Metals & Alloys, 21,* No. 1, 136 (1945). Part of "Recent Progress in Testing, Inspection and Control" – a group of articles. Developments during 1944.

(4449) Powdered Metals for Welding. *Am. Machinist, 90,* No. 11, 191 (1946). A new method of welding, brazing or surfacing with infinite compositions of powdered materials has been introduced by Powder Weld Co.

(4450) Welding with Powdered Metal. *Iron Age, 157,* No. 25, 69 (1946). Details of newly developed technique announced by Powder Weld Co., Brooklyn. Process

based on use of powdered metal spray in place of conventional welding rod.

(4451) Welding with Powdered Metal. *Metal Ind. (London), 69,* No. 15, 310 (1946). A technique of welding in which the weld metal and the flux both in powdered form are introduced into the flame via the welding torch has been developed by the Powder Weld Co., Brooklyn.

(4452) Fernico from Metal Powders. E. E. Burger, *Gen. Electric Rev., 49,* No. 12, 22-24 (1946). Fernico alloy used for glass-to-metal seals and containing about 53% Fe, 30% Ni, 17% Co, is produced by mixing, pressing and sintering very fine powders.

(4453) Powdered Metal in a Flame. C. B. Clason, *Welding Engr., 31,* No. 6, 46-48 (1946). New welding and hard facing process involving the application of powdered metals and fluxes through a torch flame.

(4454) Extruding Powdered Metals to Form Synthetic Welding Wire. F.G. Daveler, *Materials & Methods, 23,* No. 5, 1317-1320 (1946). A drawn-wire base is clad with alloying elements in much the same manner as rods are flux-coated, to produce a special application welding rod.

(4455) Telefunken Metal–Ceramic Radio Valves. G. L. Hunt, B.I.O.S. Final Rept. No. 30 (1946). This report on valve manufacture mentions a molybdenum-iron paste for metal-to-ceramic seals and a sintered Th-Al-Ce mixture as a non-evaporating getter.

(4456) Extruded Powder Metal Welding Rods. F. C. Kelley, and F. E. Fisher, *Iron Age, 158,* No. 25, 68-72 (1946). Warborn technique for producing 18-8 welding rods by extruding powder metal mixture results in rods having very satisfactory welding characteristics. Metal deposition is obtained in form of a fine spray.

(4457) Production of Beryllium Oxide and Beryllium-Copper. B. R. F. Kjellgren, *Trans. Electrochem. Soc., 89,* 247-61 (1946). The production of Be oxide from Be ore. The production of Be-Cu in an electric arc furnace by reduction of Be oxide with carbon to pure Be, then alloying with Cu by mixing the ingredient powders prior to the fusion.

(4458) Magnetic Particle Testing Prevents Railroad Failures. L. B. Sagle, *Am. Machinist, 90,* No. 3, 106-107 (1946). Flaws in forgings and castings are detected in advance through the use of ferromagnetic powder sprinkled on the locomotive parts.

(4459) Powder Metallurgy – A Study of Sintered Kovar. N. Thien-chi, *Compt. rend., 222,* 1046-47 (1946); *Powd. Met. Bull., 1,* No. 5, 82-83 (1946). Kovar (29% Ni, 17% Co, 54% Fe) was made by pressing the powdered ingredients at 3 metric tons per sq. cm. and sintering 10-20 hrs. at 1050° C. (1920° F.) or at 1250° C. (2280° F.) for 1 hr. A density of 6, 6.5, and 7.8, respectively, was obtained. Debye-Scherer pictures show that the sintered samples have same crystal structures as dense Kovar.

(4460) Ferrous Production Metallurgy. H. K. Work, and H. B. Emerick, *Mining and Met., 27,* No. 470, 86-88 (1946). Sponge iron as charge material in steel making included in review.

(4461) New Equipment: Powder Welding and Metallizing Gun. *Iron Age, 159,* No. 4, 72 (1947). As announced by Wall Colmonoy Corp., Detroit, this unit combines welding and metallizing procedure.

(4462) Sponge Iron Process for Emergencies. *Iron Age, 160,* No. 8, 124 (1947). Sponge iron produced by Bureau of Mines in pilot plants as substitute for scrap in production of tool steels.

(4463) Powdered Iron in Electrode Coatings. *Iron Age, 160,* No. 22, 75 (1947). During the war a new type of basic welding electrode was developed in Sweden which is popular in that country and on the Continent. These electrodes have a high content of iron powder in their coatings.

(4464) Sponge Iron Substituted for Scrap. *Steel, 121,* No. 19, 123 (1947). Sponge iron substituted for scrap used in production of high quality steel for tools and instruments.

(4465) Metal-Ceramic Brazed Seals. R. J. Bondley, *Electronics, 20,* No. 7, 97-99 (1947). In manufacturing tubes, efficient sealing of steatite to metal is obtained by coating the ceramic with a suspension of –300 mesh titanium hydride, applying silver alloy solder, and heating in vacuum to 1000° C. (1830° F.).

(4466) Extruding Powdered Metals to Form Synthetic Welding Wires. F. G. Daveler, *Machinery Lloyd, 18,* No. 26, 86 (1947); *J. Inst. Metals (London), Abstr. 15,* 106 (1947). Alloy welding rod composed of drawn wire clad with alloying elements, produced by powder metallurgy.

(4467) Powder Cutting High Alloys. D. H. Fleming, *Materials & Methods, 25,* 73-76 (1947). Iron-rich powder is introduced into the oxygen stream of the cutting tools to make the flame pass through the refractory oxides in the alloys.

(4468) Powder Cutting and Scarfing. D. H. Fleming, *Welding Eng., 32,* 66-67, 113 (1947). How use of a metallic powder provides a versatile process capable of handling the cutting of a wide variety of alloy compositions from ingot to finished product.

(4469) Powder Cutting and Scarfing of Oxidation-Resistant Materials. D. H. Fleming, *J. Am. Welding Soc., 26,* No. 3, 201-08 (1947). Typical scarfing and powder-cutting applications are discussed.

(4470) Magnetic Particle Inspection. S. L. Henry, *Metal Progress, 52,* No. 1, 88-90 (1947). Magnetic particles applied dry to magnetized parts; method of magnetizing is governed by the type of defect that is to be detected.

(4471) Soldered Ceramic-to-Metal Seals. A. D. Jenny, *Product Engr., 18,* No. 12, 154-55 (1947). Designs facets of a relatively simple and little known type of gasketless seal for making gas-tight joints between ceramic and metal.

(4472) Magnetic Particle Inspection of Chromium-Plated Tools. M. H. Muelier, and W. E. Yeast, *Metal Progress, 51,* No. 3, 420-25 (1947). It was found that hardened and ground tools, apparently crack-free, developed tiny surface cracks in the chromium plating bath.

(4473) Melting of Molybdenum in Vacuum Arc. R. M. Parke, and J. L. Ham, *Trans. Am. Inst. Mining Met. Engrs., 171,* 416-430 (1947). Description of 2 processes of vacuum-melting and casting the metal using briquetted powder produced by reduction from MoO_3 as starting material. Comparison with conventional powder metallurgy product. Discussion.

(4474) Use of Powdered Iron in Welding Electrode Coatings. A. F. Smith, *Sheet Metal Ind., 24,* No. 245, 1852 (1947). The basic principle of the process depends upon the protection from oxidation and nitrogen absorption which the iron affords the weld metal.

(4475) Use of Sponge Iron in Swedish Steel Production. M. Tigerschiold, *Jernkontorets Ann., 131,* 295-300 (1947). A review of the sponge iron question. Costs of production made by Wiberg method (gas reduction, Swedish Patent 46,507). and Höganäs method (reduction with coal). Steel production with charges containing 70% sponge and open hearth with additions of sponge in charge.

(4476) Use of Sponge Iron for Making Steel in Sweden. M. Tigerschiöld, and S. Eketorp, *Proc. Conf. Am. Inst. Mining Met. Engrs., 6,* 1947; *Blast Furnace, Coke Oven and Raw Mat., 177,* 94-101 (1947). In the Höganäs process the C content is below 0.1%, but in the Wiberg process Fe can take up 0.7% C; the two processes are analyzed. In the production of acid open hearth steel at Sandviken, 12-13% sponge iron was used in the charge, but now it is raised to 20%.

(4477) Metal-Ceramic Vacuum Seal. N. T. Williams, *Rev. Sci. Instruments, 18,* No. 6, 394-397 (1947); *Met. Powd. Rept., 2,* No. 3, 38 (1947). Method of metallizing a ceramic as base for vacuum tight brazing in connection with centimeter band equipment.

(4478) Large Scale Production of Metal Hydrides. H. W. Zabel, *Chem. Inds., 60,* No. 1, 37-39 (1947). A discussion is presented of titanium hydride as alloying ingredient and deoxidizer for non-ferrous master alloys such as titanium-copper or titanium metal for permanent magnets.

(4479) Chemically Heated Soldering Iron. *Machine Design, 20,* No. 11, 102 (1948). A photograph shows a soldering iron with a cartridge containing metal

powder, an oxidizing agent and a primer, inserted in a socket behind the soldering tip.

(4480) Hard Surfacing by Fusion Welding. H. S. Avery, *Steel, 123,* No. 15, 96, 107-108 (1948). Improved resistance of armoring parts to severe wear, corrosion, or heat can be secured by depositing an overlay on the surface by use of Fe-base welding rods, containing Ni, Co, W, Si, carbides, nitrides or borides.

(4481) Powder Process in Stainless Steel Production. J. Busch, and E. M. Holub, *Blast Furnace Steel Plant, 36,* 443-444 (1948). The powder process is of great value for scarfing and conditioning stainless steel ingots. The reaction zone is fed with powder which gives increased heat and acts as a flux to remove the Cr oxide and the non-oxidizing Ni. Fe rich powder of a fine mesh size is used.

(4482) Powder Welding. C. B. Clason, *Welding Engr., 33,* No. 2, 60-62 (1948). Metal powder, rubber and enamels can be flame applied with a controlled atmosphere. The materials and the equipment are described.

(4483) Metal Joining with Paste Type Fusion Alloys. D. C. Dilley, *Machine Design, 20,* No. 12, 146-8 (1948). A series of metal powder containing solder pastes by Fusion Engineering Co. has been developed for joining parts of aluminum, stainless steel, copper, silver, brass and carbides.

(4484) Powder Cutting as Production Tool. D. H. Fleming, *J. Am. Welding Soc., 27,* No. 3, 181-87 (1948). Powder cutting costs; effect of powder cutting on cut edge; minimizing the heat effect; powder cutting equipment.

(4485) Metal Powders in Industrial Brazing. H. W. Greenwood, *Mech. World, 123,* 190-193 (1948). Advantages are claimed for brazing of flame-sprayed parts. Large parts can be given very thin adherent coating of brazing material.

(4486) Metals and Ferrous Alloys Used in the Manufacture of Steel. G. K. Herzog, *Metals Handbook.* Am. Soc. Metals, Cleveland, 1948, pp. 337-340. A discussion of composition, properties and uses of various commercial ferro-alloys is given.

(4487) Laramie Sponge Iron Pilot Plant. T. L. Johnston and W. M. Mahan, *U. S. Bur. Mines, Rept. Invest. No. 4376,* 44 pp., 1948. The production in a large rotary kiln was determined in 40 separate tests with ores from Wyoming, California, and Arizona; coal from Wyoming, Arizona; coke from Colorado. A carload of Fe pellets was used in open-hearth furnace; the briquetted sponge iron was made into steel in electric furnace.

(4488) Iron Production by Methods Other than Coke Blast Furnace. E. C. Smith, *Yearbook Am. Iron Steel Inst.,* 41 pp. (1948). The unsuccessful experiments of Republic Steel Corp. with a sponge Fe plant are described. The only satisfactory method for reduction of Fe ore is the blast furnace.

(4489) Use of Sponge Iron for Steelmaking. M. Tigerschiöld, and S. Eketorp, *Metallurgia, 37,* No. 220, 167-77 (1948). Several sponge iron methods have been developed, but so far the Höganäs and Wiberg methods are the only ones operating which are discussed in the paper.

(4490) Glass-to-Metal Seals. *Metal Ind. (London), 75,* 263-66, 292-93 (1949). The application of iron-nickel-cobalt alloys for sealing is given.

(4491) Aluminum-Vinyl Cold Solder. E. L. Cady, *Materials and Methods, 30,* No. 4, 77-79 (1949). Putty-like filler pastes composed of aluminum powder and vinyl resin have many potential uses as repair material.

(4492) Brazing and Soldering—Applications of Metal Powder Technique. H. W. Greenwood, *Metal Ind. (London), 75,* No. 10, 191-2 (1949). Use of brazing and soldering alloys in powder form discussed; examples of their successful application reported; important savings effected.

(4493) Melting and Casting Zirconium. W. J. Kroll, and H. L. Gilbert, *J. Electrochem. Soc., 96,* 158-69 (1949). Describes further work done at U. S. Bur. Mines using an arc furnace, a high-frequency furnace, both with helium atmosphere and a three-phase split-tube graphite resistor furnace for vacuum melting. Briquetted powder used in part of the work.

(4494) New Brazing Method for Joining Nonmetallic Materials to Metals. C. S. Pearsall, *Materials & Methods, 30,* No. 1, 61-62 (1949). Ceramics,

carbides, diamonds are brazed to metal by coating the latter with a hydride, *e.g.*, zirconium hydride, as a suspension in water or nitrocellulose, placing upon it a piece of Cu or Ag as solder, and heating it in dry hydrogen.

(4495) Production and Arc Melting of Titanium. O. W. Simmons, C. T. Greenidge, and L. W. Eastwood, *Titanium Symposium*, Off. Naval Res., Washington, D.C., 1949, pp. 77-91 (1949). The furnaces at Battelle Memorial Institute are described.

(4496) Induction Melting of Titanium in Graphite. J. B. Sutton, *Titanium Symposium*, Off. Naval Res., Washington, D.C., 1949, pp. 73-76. Describes the melting and casting unit developed by E. I. du Pont de Nemours & Co. The charge consists of crushed sponge particles.

(4497) Copper Paste Simplifies Brazing. K. Wunsch, *Iron Age, 164*, No. 25, 76-77 (1949). A copper paste, replacing copper wire rings in furnace-brazing increases the efficiency of the brazing operation. The paste, known as Cubond 151, contains 22.5 lbs. of Cu per gallon as a suspension of cuprous oxide in either a synthetic petroleum base or in a base that does not change in viscosity with change of temperature. The Cu paste contains a wetting and anti-spatter agent and fluxes of H_3BO_3. Technique of application is described.

D. Applications for chemical and related industries (chemical reagents and catalysts; heat generating agents; pyrotechnics)

(4498) Iron Carbide and Its Catalytic Effect. S. Hilpert, and T. Dieckmann, *Ber. deut. chem. Ges., 48*, 1281 (1915). The thermal decomposition of CO in iron powder containing graphite is investigated.

(4499) Aluminum Dust. G. H. Clevenger, *Mining Sci. Press, 112*, 118 (1916). Al dust for explosives; analysis is given.

(4500) Study of Catalytic Action at Solid Surfaces. E. F. Armstrong, and T. P. Hilditch, *Roy. Soc. Proc., A97*, 259-64 (1920). Hydrogenation of acetaldehyde and the dehydrogenation of ethyl alcohol in presence of finely divided metals is described.

(4501) Reduction of Pyridine with Zn Dust and Acetic Anhydride. O. Dimroth, and R. Heene, *Ber. deut. chem. Ges., 54B*, No. 2, 2934-42 (1921). Tests prove that pyridine alone mixed with Zn-dust and anhydrous acetic acid may produce crystals of a yellow color.

(4502) Study of Ammonia Catalysts. A. T. Larson, and R. S. Tour, *Chem. & Met. Eng., 26*, 647-56 (1922). Impurities in metal catalysts are discussed.

(4503) Increasing Ammonia Production with Catalysts. A. T. Larson, *Ind. Eng. Chem., 16*, 1002-04 (1924). A discussion is given of impurities which act as promoters in metal catalysts.

(4504) Preparation of Fused Iron Oxide for Catalysts. A. T. Larson, and C. N. Richardson, *Ind. Eng. Chem., 17*, 971-72 (1925). Metal catalysts, prepared by the reduction of their fused oxides, are treated.

(4505) Precipitation Efficiency of Zinc Dust in Cyanide Process. R. Lepsoe, *Trans. Am. Inst. Mining Met. Engrs., 71*, 1061-5 (1925). The method devised by W. J. Sharwood is proved to be satisfactory; the tests were merely for comparison of different samples, hence the personal factor in the manipulation was eliminated.

(4506) Poisoning Action of Oxygen on Iron Catalysts for Ammonia Synthesis. J. A. Almquist, and C. A. Black, *J. Am. Chem. Soc., 48*, 2814-20 (1926). The effect of poisons (inhibitors) and promoters on metal powder catalysts is discussed.

(4507) Use of Copper Powder in Analytical Chemistry. K. Kürschner, and K. Scharrer, *Z. anal. Chem., 68*, No. 1, 1-14 (1926). Admixing of Cu powder to the material, *e.g.*, calcium cyanamide, in the Kjedahl-flask.

(4508) Report on Contact Catalysis. H. S. Taylor, *J. Phys. Chem., 30,* 145-71 (1926). A theory is postulated which maintains that catalysts are active by virtue of the presence of certain "active points" or centers on the surfaces of the particles.

(4509) The Catalytic Properties of Chromium Oxide. W. A. Lazier, and J. W. Vaughen, *J. Am. Chem. Soc., 54,* 3080-95 (1932). The specificity of catalysts is discussed.

(4510) Activity and Crystal Structures of Mixed Metal Catalysts. J. H. Long, J. C. W. Frazer, and E. Ott, *J. Am. Chem. Soc., 56,* 1101-07 (1932). The specificity of certain catalysts for certain reactions is mentioned.

(4511) J. Maxted, and A. Churchill, *Catalysis and Its Industrial Applications.* London, 1933, 530 pp. A discussion of activity of iron is given on pp. 414, 435, and 467; preparation of iron is mentioned on p. 225; and the preparation of nickel is referred to on pp. 218 and 447.

(4512) R. Q. Brewster, and T. Groening, *Organic Syntheses,* Vol. 14, Wiley, New York, 1934. Pages 66-7 on nitrodiphenyl ether includes details on the preparation of copper powder.

(4513) Reactivity of Gaseous Nickel Carbonyl. S. S. Urazovskii, and N. A. Yakimkin, *Ukrain. Khem. Zhur., 10,* 44-50 (1935). The reactions $CO + 3H_2 \rightarrow CH_4 + H_2O$ and $2CO \rightarrow CO_2 + C$ are more powerfully catalyzed by $Ni(CO)_4$ at its decomposition temperature (150° C. – 300° F.) than by other Ni catalysts.

(4514) Gel System: Cellulose Nitrate–Copper Bronze. W. E. Gloor, and H. M. Spurlin, *J. Am. Chem. Soc., 58,* 854-5 (1936). Bronzing powders and copper salts are added to cellulose nitrate solutions to give a clear gel.

(4515) R. H. Griffith, *Contact Catalysis,* Oxford Univ. Press, Oxford, 1936, 273 pp. Contains information on the structure of metallic films on p. 157, and on nickel catalysts on pp. 142, 160, 166.

(4516) Influence of Electrolytes on Reduction of Nitrates with Copper Magnesium and Copper Zinc Dust. T. Arnd, and H. Segeberg, *Z. angew. Chem., 50,* No. 4, 105-7 (1937). Comparison of the reduction power of Cu-Zn dust and Cu-Mg-alloy in alkali solutions.

(4517) Accumulation of Alkali Promoters on Surfaces of Iron Synthetic Ammonia Catalysts. P. H. Emmett, and S. Brunauer, *J. Am. Chem. Soc., 59,* 310-15 (1937). Potassium oxide in iron synthetic ammonia catalyst actually covers more than 50% of the total surface.

(4518) U. S. Bureau of Mines Experimental Plant. H. H. Storch, L. L. Hirst, P. L. Golden, I. I. Pinkel, R. L. Boyer, J. R. Schaeffer, and R. H. Kallenberger, *Ind. Eng. Chem., Ind. Ed., 29,* 1377-80 (1937). Metal punchings, filings, or rods have been used for high temperature catalytic reactions.

(4519) Powdered Aluminum and Magnesium in Explosives and Pyrotechnics. *Light Metals, 1,* 34 (1938). A review.

(4520) Zinc Dust Fusion; A New Method for the Reduction of Organic Compounds. E. Clar, *Ber. deut. chem. Ges., 72B,* No. 9, 1645-9 (1939). Zn-dust effects a strong reduction at low temperatures in a melt of $NaCl–ZnCl_2$.

(4521) Effect of Aluminum on Solution of Mine Dust. S. R. Rabson, *Trans. Inst. Mining Met. (London), 48,* 651-655 (1939). Addition of Al powder to mine dust lowers the initial rate but does not affect the ultimate solubility of dusts.

(4522) National Research Council, Committee on Contact Catalysis, *12th Report,* Wiley, New York, 1940, 388 pp. Contains articles dealing with metals as catalysts.

(4523) Heats of Adsorption of Gases on Iron Synthetic Ammonia Catalysts. R. A. Beebe, and N. P. Stevens, *J. Am. Chem. Soc., 62,* 2134-39 (1940). The heat evolved during the adsorption of oxygen on iron catalysts was measured.

(4524) S. Berkman, J. Morell, and G. Egloff, *Catalysis.* Reinhold, New York, 1940, 1130 pp. The activity of metal catalysts is described in Chapter 4, pp. 222-306.

(4525) Suitability of Recovered Dow Metal Powder in Pyrotechnic Compositions. C. G. Dunkle, Picatinny Arsenal Tech. Rept. 1116; U. S. Dept. Commerce, Off. Pub. Bd. Rept. PB 3104 (1941). Dow metal recovered by special process from grindings and scrap was studied by the Arsenal as substitutes for Mg and Al in pyrotechnic compositions.

(4526) Formation of an Azulene On Zinc-Dust Distillation of Pyrethrosin. M. S. Schechter, and H. L. Haller, *J. Am. Chem. Soc., 63,* No. 12, 3507-10 (1941). Pyrethrosin on Zn-dust distillation yields about 1.5% of a new azulene.

(4527) Metallic Catalysts. P. H. Emmett, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 13, pp. 155-165. Factors influencing the activity of catalysts; methods of preparation, reactions.

(4528) Precipitation of Gold from Cyanide Solution by Zinc Dust. R. Leblanc, *Can. Mining J., 63,* No. 4, 213-9; No. 5, 297-306, No. 6, 371-9 (1942). Theoretical aspects of the precipitation of Zn. The influence of certain factors. Apparatus and procedure; conclusions; bibliography.

(4529) The Catalytic Behavior of Copper Powder of Different Thermic Preliminary Treatment Against the Decomposition of Formic Acid Vapor. K. Sedlatschek, *Kolloid-Z., 104,* No. 2/3, 203-208 (1943). Test results discussed.

(4530) Use of Zinc Dust in the Purification of Zinc Plating Solutions. M. Diggin, *Metal Finishing, 42,* 344 (1944). To produce acceptable zinc deposits, alkaline Zn plating solutions must be free from heavy metal impurities. Deposits containing heavy metal impurities do not have as high a protective value as pure electrolytic Zn.

(4531) Preparation and Properties of Metal Carbides. L. J. E. Hofer, *U. S. Bur. Mines Rept. Invest. No. 3770,* 1944, 39 pp. Critical comment as to their significance in the Fischer-Tropsch synthesis. Cracking of carbon monoxide on Ni, Fe, Co.

(4532) Powder Metals as Viewed by the Army. L. J. Pasternak, *Iron Age, 153,* No. 22, 58 (1944). Deals chiefly with pyrotechnics and explosives.

(4533) Metal Powders in Pyrotechnics and Military Explosives. L. J. Pasternak, *Metals & Alloys, 20,* No. 2, 436 (1944). An abstract is given from a paper given at the Metal Powder Assoc., First Ann. Spring Meeting, May 5, 1944. Mg and Al powders used in flares, etc. are described.

(4534) Aluminum Powder as a Heat Generator. *Light Metal Age, 4,* No. 9, 7 (1946). Editorial on what to do with huge quantities of left-over Al powder from war production.

(4535) Application of Aluminum Powder in Heating Elements. Deutsche Pulvermetallurgische Gesellschaft, F.D. Rept. No. 1725/46 (1946). Manufacture of electrical hotplates by imbedding the element in partially oxidized aluminum powder; work covers period of 1939 to 1945.

(4536) Hot Plates with Powder Metals. *Machinery (London), 70,* 509 (1947). Designs of hot plates containing powdered aluminum made in Germany.

(4537) Few Powders of Metals Burn. *Steel, 120,* No. 19, 121 (1947). Dust clouds of Al were found capable of producing strong explosions.

(4538) Metallothermy in the Light of Electrochemical Series. T. Iskol'dskii and T. G. Shokhor, *J. Applied Chem. (U. S. S. R.), 19,* 693-99 (1947); *Chem. Abstr., 41,* No. 14, 4423 (1947). Reactions investigated between powdered (70 mesh) metals and oxides, in batches of 25 grains oxide, 3 NaFe as flux, 19 BaO_2 and 1 metal powder as initiator. Kindled by a Mg ribbon.

(4539) Vanadium Catalyst. W. J. Carter, *Alloy Metal Rev., 5,* No. 45, 2-5 (1948). Types of catalysts; methods of testing V catalyst; equilibrium reaction; reaction chambers.

(4540) Reduction of Antimony Solutions with Nickel. H. Holness, *J. Soc. Chem. Ind., 67,* 238-41 (1948). Using 5.0 g. of fine Ni powder, solutions containing up to 1.5 g. of Sb in 100 ml. of dilute HCl were reduced in 20 min., provided the solution was undisturbed, and was heated in a water bath.

(4541) Knowledge of Ion Exchange in Slag and Water. Y. Kauko, *Met. Powd. Rept., 2,* No. 12, 180; *Oesterr. Chem. Ztg., 49,* No. 10/11, 197 (1948). Intern. Powder

Metallurgy Conference, Graz, Ref. No. 59. Calometric measurement showed that the rate of ion exchange of basic iron slag in water was highly temperature-dependent between 22.5 and 50° C. (72 and 122° F.).

(4542) Titration of Iron in High Temperature Alloys. L. Silverman, *Steel, 122,* No. 4, 66 (1948). Use of copper powder reduction method simplifies determination of iron in presence of Ni, Cr, W, Al.

(4543) The Thermit Process. *Welding, 17,* 94-103 (1949). Thermit for present-day welding consists of a mechanical mixture of finely divided aluminum and processed iron oxide; Mn and C may be added, and if required, Mo, Ni, Cr. The mixture is safe at ordinary temperatures.

(4544) Laboratory Experiments of Aluminum and Zinc Dusts in Cyanidation Practice. W. Hutchings, *Can. Mining J., 70,* No. 10, 74-9 (1949). Author has established at the Canadian Bureau of Mines that gold ores can be treated with Al, quantities smaller than with Zn, and the cyanide solution being regenerated automatically.

E. Addition agents and coatings for metal bases (coating, spraying, vapor deposition, and electro-plating; cladding; molding; hard facing; cementation)

(4545) Calorizing – A Protective Treatment for Metal. H. B. C. Allison, and L. A. Hawkins, *General Electric Rev., 17,* No. 10, 947-951 (1914). Calorizing will prevent metals, especially iron, from burning when subjected to high temperatures. The life of Cu contacts can be increased by calorizing.

(4546) The Schoop Metal Spray Process, Its Development and Applications. M. U. Schoop and H. Gunther, *Das Schoopsche Metallspritzverfahren.* Frankh'sche Verlagsbuchhandlung, Stuttgart, 1917, 263 pp. The use of metal powders as starting materials. A review is given of the position of the process relative to other metallizing processes. A broad outline of the patent history is also presented.

(4547) Calorizing. R. June, *Metal Ind. (N. Y.), 19,* No. 8, 336-337 (1921). A review. Advantage of the calorizing process is that the protective element is not put on in form of a skin, but enters into intimate association with the metal, forming a solid mass.

(4548) Production and Characteristics of the Carbides of Tungsten. M. R. Andrews, *J. Phys. Chem., 27,* 270-83 (1923). At the surface of an incandescent tungsten filament above 870° C. (1600° F.) $C_{10}H_8$ is quantitatively decomposed, its entire C content uniting with the W. The filament is converted first into W_2C and then into WC, both of which are brittle.

(4549) An Attempt to Electroplate Tungsten on Iron. C. A. Mann, and H. O. Halvorsan, *Trans. Am. Electrochem. Soc., 45,* 493-510 (1924). Attempts to electrolyze a solution of tungsten chlorides produced only a surface film of oxide, which prevents further electrolysis.

(4550) Cementation of Iron. J. Laissus, *Compt. rend., 182,* 465-67 (1926). The cementation of iron parts by imbedding them into packs of ferrotungsten or tungsten powders has been suggested as a method of obtaining improved acid resistance.

(4551) Refining of Surfaces of Metals by Diffusion. G. Grube, *Z. Metallkunde, 19,* 438-47 (1927). Diffusion processes in metals or on their surfaces are strongly influenced by minor quantities of impurities or addition elements in the protective atmosphere. This is of significance in surface impregnation work with the aid of powder packs.

(4552) Refinements of the Surface of Metals by Diffusion. G. Grube, and K. Schneider, *Z. anorg. allgem. Chem., 168,* 17-30 (1927). Steel can be surface-impregnated by packing in tungsten or ferro-tungsten powder and heating in

hydrogen until penetration by the diffusion of tungsten in iron has reached the desired thickness.

(4553) Use of Metal Powders for the Production of Coatings. A. Karsten, *Oberflächentechnik, 7,* No. 18, 173-175 (1930). Describes a number of applications, including metallized paper, wood, concrete, X-ray equipment, Zeppelin fabrics, etc. Aero-engine repairs are carried out with a cold spray.

(4554) The Electrodeposition of Tungsten from Aqueous Solutions. C. G. Fink, and F. L. Jones, *Trans. Electrochem. Soc., 59,* 461-81 (1931). The conditions for the electrodeposition of a bright metallic tungsten film from a sodium tungstate solution are presented.

(4555) Effects of Carbon and Iron in Blue Powder on Sherardizing. M. Kuroda, *Bull. Inst. Phys. Chem. Res.,(Tokyo), 10,* 698-702 (1931). Catalytic acceleration of sherardizing process.

(4556) Diffusion from Sprayed Metal Coatings into Steel. P. Bardenheuer, and R. Müller, *Mitt. Kaiser Wilhelm Institut Eisenforschung, 14,* No. 20, 295-305 (1932). Experimental procedure described. Powdered metals used for spraying 0.05% C steel were: chromium, mixture of Cr and Ni; mixture of Cr and Al; Cr-Fe-Si alloy; Cr-Fe-Ni alloy; Cr-Ni-Al and Cr-Al alloys.

(4557) Electrodeposition of Tungsten from Aqueous Alkaline Solutions. M. L. Holt, and L. Kahlenberg, *Quart. Rev. Am. Electroplaters' Soc., 19,* No. 9, 41-52 (1933). A report is given on an extensive survey of possible plating solutions for use in the electrodeposition of metallic tungsten. Under the best conditions, only a very thin film of W can be obtained.

(4558) Cementation of Zinc into Some Metals by Means of Zinc Dust. T. Kase, *Kinzoku-no-Kenkyu, 10,* 555-72 (1933). Cementation of metals and alloys (Fe, Cu, Ni, brass, etc.) by Zn dust.

(4559) Metallic Cementation I. T. Kase, *Kinzoku-no-Kenkyu, 11,* 43-56 (1934). Sherardizing; cementation of Cu by Zn powder; effects of catalysts, temperature, time and atmosphere.

(4560) Metallic Cementation II. T. Kase, *Kinzoku-no-Kenkyu, 11,* 251-62, 274-82 (1934). Cementation of some metals by means of antimony dust.

(4561) Protection of Oxidizable Metals. A. Vila, *J. usines gaz., 58,* 655-7 (1934). Use of pitch and aluminum powder.

(4562) Schori Metal Spraying Equipment. *Machinery (London), 46,* 806-7 (1935). Spray pistol uses metal powders, such as Al, Pb, Cu, Ni.

(4563) Metallic Cementation by Means of Aluminum Powder. T. Kase, *Kinzoku-no-Kenkyu, 12,* 49-66, 120-8, 159-67 (1935). Cementation of Cu, Fe and Ni by Al.

(4564) Metallic Cementation by Means of Tin Powder. T. Kase, *Kinzoku-no-Kenkyu, 12,* 210-19, 257-66, 301-8 (1935). Cementation of Cu, Fe, and Ni by Sn.

(4565) Metallic Cementation by Means of Chromium Powder. T. Kase, *Kinzoku-no-Kenkyu, 12,* 357-70 (1935). Cementation of Fe and Ni by Cr.

(4566) Metallic Cementation by Means of Silicon Powder. T. Kase, *Kinzoku-no-Kenkyu, 12,* 397-410 (1935). Cementation of Cu, Fe, Ni by Si.

(4567) Metallic Cementation by Means of Manganese Powder. T. Kase, *Kinzoku-no-Kenkyu, 12,* 478-83, 507-13 (1935). Cementation of Cu, Fe, Ni by Mn.

(4568) Cementation of Iron and Ferrous Alloys with Beryllium. J. Laissus, *Rev. mét., 32,* 293-301 (1935). Be and Fe-Be powders used in the process.

(4569) W. Espe, and M. Knoll, *Werkstoffkunde der Hochvakuumtechnik.* Springer, Berlin, 1936. The surface treatment of metals is dealt with on pp. 150-56.

(4570) Cementation of Some Metals by Means of Ferro-Titanium Powder. T. Kase, *Kinzoku-no-Kenkyu, 13,* 50-9 (1936). Cementation of Cu, Fe and Ni by Fe-Ti alloy.

(4571) Cementation of Some Metals by Means of Beryllium Powder. T. Kase, *Kinzoku-no-Kenkyu, 13,* 173-88 (1936). Cementation of Fe, Ni and Cu by Be.

(4572) New Method of Spraying Al and Other Metals. C. F. Lumb, *Aluminum and Non-Ferrous Rev., 2,* 45-7 (1936). Schori metal spraying process described.

(4573) Uniform Loading of Lines by Magnetic Coating (in English). K. Tsukamoto, *Nippon Elec. Commun. Engineering* , (Special No., Dec. 1936), 452-5 (1936). Wires coated with Permalloy dust or "Sendust." By passing a direct current through the wire while it is being coated with the magnetic particles a magnetic field is induced and the particles will align themselves parallel to the magnetic lines.

(4574) Production of Metallic Coatings from Powders. E. Antoshin, *Mashinostroitel, 5,* 12-14 (1937) (in Russian). Methods discussed; viewpoint of saving metals is underlined.

(4575) Cementation of Tungsten on Some Metals. T. Kase, *Kinzoku-no-Kenkyu, 14,* 22-34 (1937). Cementation of Fe and Ni and Cu with W.

(4576) Cementation of Molybdenum on Some Metals. T. Kase, *Kinzoku-no-Kenkyu, 14,* 75-86 (1937). Cementation of Fe and Ni with powdered Fe-Mo.

(4577) Cementation of Some Metals with Vanadium. T. Kase, *Kinzoku-no-Kenkyu, 14,* 120-9 (1937). Cementation of Fe and Ni with powdered Fe-V.

(4578) Cementation of Some Metals with Tantalum. T. Kase, *Kinzoku-no-Kenkyu, 14,* 130-7 (1937). Cementation of Fe and Ni with Fe-Ta.

(4579) Metal Spraying. E. C. Rollason, *Metal Treatment, 3,* 118-25, 130; *J. Inst. Metals, 60,* 35-57 (1937). Comparison tests made of sprayed coatings from wire, powder and molten metals.

(4580) A New Method Of Metal Spraying. *Engineer, 166,* No. 4315, 318 (1938). Schori metal powder spraying method.

(4581) Leaded Grease Increases Life of Dredge Parts. *Eng. Mining J., 139,* No. 11, 38; *Lead, 8,* No. 4, 4-5 (1938). Powdered Pb used as addition agent.

(4582) Metal Spraying: Fundamentals and Applications. R. L. Dennison, *J. Am. Soc. Naval Eng., 50,* No. 1, 85-106 (1938). Schori process included in discussion.

(4583) Protection of Base Metals by the Use of Metallic Coatings. C. E. Heussner, A.S.T.M. Symposium on Protecting Metals Against Corrosion, Philadelphia, Pa., pp. 6-15 (1938). Discussion includes Schori method.

(4584) Metallic Cementation: Cementation of Boron on Some Metals. T. Kase, *Nippon Kinsoku Gakkai-Si, 2,* No. 6, 261-70 (1938). Cementation by B or Fe-B.

(4585) The Oxide-Coated Filament: The Relation between Thermionic Emission and Content of Alkaline Earth Metal. C. H. Prescott, and J. Morrison, *J. Am. Chem. Soc., 60,* No. 12, 3047-53 (1938). Using a tungsten filament coated with colloidal mixture of barium oxide, strontium oxide, finely divided nickel, and free alkaline earth metal to investigate the quantitative emission of the content of active metal.

(4586) Corrosion Protection by Spraying Process. *Sheet Metal Worker, 30,* No. 4, 29, 68 (1939). Uses of powdered zinc, rubber, and other materials sprayed through a flame to provide corrosion protection to metal surfaces.

(4587) N. F. Budgen, and T. H. Turner, *Metal Spraying.* Lipincott, Philadelphia, 1939. Spray guns using powder instead of wire.

(4588) Metal Powder Spraying. J. W. Gibbons, *Power, 83,* 194-195 (1939). Schori spray gun for metal powders and plastics.

(4589) Hard Facing Technique. T. B. Jefferson, *Welding Eng., 24,* 37-39 (1939). Welded overlays of cemented carbide give a composite structure possessing the best combination of physical properties.

(4590) E. C. Rollason, *Metal Spraying.* Griffin, London, 1939, 235 pp. The development of modern spraying pistols. The nature of sprayed metals. Application of the metal-spraying process.

(4591) Powder Metallurgy in War and Peace. *Metal Ind. (London), 56,* No. 6, 147-48 (1940). Corrosion-resistant surfaces on base metals can be obtained by burning amalgams or zinc alloys of higher melting metals, *e.g.*, tungsten.

(4592) Investigation on Mechanism of Cementation of Metals. M. Goto, H. Asada, and T. Okamoto, *Rept. Aeronaut. Research Inst., Tokyo Imp. Univ.*, No. 200,

15, No. 14, 431-76 (1940). Cementation of Mo-coatings on nickel studied; also effect of Cr, Cu, Fe.

(4593) Preliminary Investigations on Plating with Titanium and Titanium Alloys. N. N. Gratsianskii, and A. P. Vovkogon, *Zapiski Inst. Khim. Akad. Nauk, U. R. S. S.*, *7*, No. 2, 173-76 (1940). Literature review of earlier work on isolation of metallic Ti by three groups of processes including electrodeposition. Description of authors' studies of electrodeposition of straight Ti-Al alloys, from aqueous solutions and from fused salt mixtures: Ti was deposited on a copper cathode from an electrolyte of sulfanilic acid and $Ti(OH)_2$; from a fused $AlCl_3$–NaCl–NaF bath, a Zn–Ti alloy was deposited on copper and iron cathodes.

(4594) Hard Facing Technique. T. B. Jefferson, *Welding Eng.*, *25*, 32-34 (1940). Results of tests with ferrous alloys and non-ferrous alloys as base for cemented carbide and other hard metal facings.

(4595) The Use of Carbonyl Nickel for the Production of Clad Sheet. L. Schlecht and G. Trageser, *Metallwirtschaft*, *19*, No. 4, 66-68 (1940). Carbonyl nickel powder was pressed into 2-ton ingots and sintered in hydrogen at 1150° C. (2100° F.) into dense blocks while supported by steel; the assemblages were subsequently welded together and rolled into thin bimetal sheet and strip.

(4596) Pistol that Sprays Powdered Metals and Plastics. R. G. Skerrett, *Compressed Air Mag.*, *45*, No. 1, 6057-60 (1940). The Schori pistol is described.

(4597) Metal Spraying. *Iron Age*, *147*, No. 6, 46-50 (1941). Schori powdered zinc gun finding wide application. Process can be used when galvanizing is impractical.

(4598) Surface Treating of Steel by Chromium Diffusion. G. Becker, K. Daeves, and F. Steinberg, *Stahl u. Eisen*, *61*, No. 12, 289-94 (1941); *Z. ver. deut. Ing.*, *85*, 127-29 (1941). A description is given of chromizing, *e.g.*, by means of a gaseous halide being passed over a chromium powder pack, for the production of a protective coating on steel.

(4599) Surface Treating by Chromizing. K. Daeves, G. Becker, and F. Steinberg, *Metallwirtschaft*, *20*, 217-220 (1941). The process of chromium surface impregnation of steel surfaces by means of a halide gas passing through a chromium powder pack is described, and test results are given.

(4600) The Development of Plating. W. Engelhardt, *Z. Metallkunde*, *34*, 12-16 (1942). A theory of the processes which occur in the bonding of metals in deposits is developed.

(4601) Spraying of Tungsten. M. U. Schoop, *Korrosion und Metallschutz*, *18*, 243-44 (1942). Spraying of tungsten carbide and tungsten on metallic objects, *e.g.*, tools, to save sintering and brazing operations. Use of wire or powder as starting material; physical phenomenon observed in spraying.

(4602) Hard Surfacing of Metals. *Mech. World*, *113*, No. 2938, 437-8 (1943). Details of certain materials and methods; development, electric arc welding, hard facings of oil well drilling bits.

(4603) Selecting Metallic Coatings for Machine Parts. R. K. Lotz, *Machine Design*, *15*, No. 10, 87-90, 282, 284, 288 (1943). Properties of most metallic coatings presented. Includes coatings originating from metallic powders.

(4604) Powder Metal Spray. *Western Mach. & Steel World*, *36*, 348-349, 373 (1945). It is now possible to apply a known thickness on metal parts and sheet surfaces with every pass of Glaspray gun by using powder metal in readily obtainable commercial sizes.

(4605) Powdered Metal Spray. C. Caredio and G. Duccini, *Western Mach. & Steel World*, *36*, No. 8, 348-9, 373 (1945). Metal spraying method described, using powdered metal or plastics.

(4606) Coatings from Metallic Hydrides of Titanium. *Am. Exporter (Indus.)*, *139*, No. 3, 30 (1946). Pure Ti made by Metal Hydrides Inc. from powdered hydrides is pressed and heated in vacuo between 400-500° C. (750-930° F.). At 900° C. (1650° F.) it spreads like oil in thin layer over copper surface, resulting in a coating harder than copper.

(4607) Flame Spraying in the Food Industry. *Food Manufacture*, *21*, No. 9, 400 (1946). Schori process of flame spraying metal powders is being used for giving

Sn and Zn coatings to a wide variety of equipment in the food industry.

(4608) Diffusion on Zinc in Light Alloys. J. Grillat, *Groupement Franc. Develop. Recherches Aeronaut., Note Tech., 58,* 1946, 19 pp. Duralumin and Duralin were coated with Zn by electrodeposition, spraying, immersion, and by heating in Zn powder.

(4609) Protection of Iron and Steel by Metallic Coatings. J. C. Hudson, and T. A. Banfield, *J. Iron Steel Inst., 154,* No. 2, 229P-264P (1946). Experimental details of coat application; discussion of results of atmospheric corrosion tests, and of the total-immersion tests in sea water.

(4610) Flame Spraying. W. D. Jones, *Metal Ind. (London), 68,* No. 4, 63-5 (1946). Various applications are illustrated and described exemplifying developments in use of sprayed coatings as corrosion protection measures. Schori powder flame spraying equipment explained.

(4611) New Metallizing Technique. J. A. Looney, *Petroleum Processing, 1,* 290-291 (1946). Refining equipment can be protected by a new metal-spraying process which eliminates the porosity, and makes it more resistant to corrosion and abrasion than the conventional coatings.

(4612) Stainless Steel Powder Uses Discussed. *Chem. Eng. News, 25,* 1740 (1947). Using a gun or torch in conjunction with a flux, a clean, bright metal coat of uniform structure can be applied to the base metal.

(4613) Tungsten Alloy Electrodeposition. *Iron Age, 160,* No. 23, 70 (1947). Tungsten alloy deposits which retain hardness at elevated temperatures on metal surfaces have been produced by method of electrodeposition reported by the National Bureau of Standards.

(4614) Metal Protection by Metal Powder. *Machinery Lloyd, 19,* No. 17, 99-100 (1947). The value of metal coating, in particular, zinc, with the Schori powder process is discussed.

(4615) Application of Flame Spraying. *Machinist (European Ed.), 91,* No. 26, 299 (1947). Two methods are described: (*1*) a sprayed coating of Cr-Ni alloy is painted with a sealer containing Al; (2) Al is applied to Cr-Ni coating by spraying, and the sealer is applied thereafter.

(4616) Flame Spraying of Metals and Plastics. *Paint Manuf., 17,* 154 (1947). Recent development using powder process.

(4617) Electrodeposition of Tungsten Alloys. *Steel, 121,* No. 26, 63 (1947). Process developed by National Bureau of Standards deposits thick, smooth coating that retains hardness at elevated temperature.

(4618) Metallizing. R. W. Bolz, *Machine Design, 19,* No. 1, 105-110 (1947). Field of metal spraying well covered. Metallizing equipment, *e.g.*, for spraying a wire with metal powder in U. S. is described.

(4619) Cu-Ti Alloy Coating on Mild Steel. E. J. Chaplin, and C. R. Hayward, *Trans. Am. Soc. Metals, 38,* 909-956 (1947). Study of Titanising process applied to iron or steel tested several methods of applying coating. Coatings prepared by brushing Cu-plated steel specimens with −300 mesh Ti-hydride in alcohol, or by applying tamped layers of Cu-Ti powder or by using a precast 28% Ti-Cu alloy.

(4620) Metallization of Aluminum. C. R. Draper, *Light Metals (London), 10,* No. 110, 124-60 (1947). Metal powders are mentioned in review which covers Al plating, dipping, spraying process and Al paint.

(4621) Flame Spraying by Powder Pistol. W. D. Jones, *Foundry Trade J., 81,* No. 1591, 157-160 (1947). Details of Schori powder flame spraying process, equipment and applications.

(4622) Flame Spraying by the Powder Pistol. W. D. Jones, *Sheet Metal Inds., 24,* No. 238, 375-82 (1947). The author deals with the conditions governing the process and discusses the metallic and non-metallic protective coatings.

(4623) Electrolytic Production of Tungsten-Cobalt, Tungsten-Nickel, and Tungsten-Iron Alloys. H. Offermanns, and M. Stackelberg, *Metalloberfläche, 1,* No. 6, 142-144 (1947). Review of history of tungsten deposition. Description of process for electrolytic production of alloys of iron, cobalt, and nickel containing up to 50% tungsten, as developed by authors. Data on composition and maintenance of a constant metal content of electrolyte.

(4624) Spray-on Zinc-Coating Methods. I. Richards, *Org. Finishing, 8,* No. 8, 30-31 (1947). Spraying pure molten metals satisfactorily with Al, Cu, Pb, Sn, Cd of wire or powder.

(4625) How to Select Hard-Facing Materials. H. W. Sharp, *Iron Age, 160,* No. 1, 62-63 (1947). Carbides of chromium have hardness values from 71 to 75 Rockwell-C; W-carbide 85-90 Rockwell-C. Rock bits are hard-faced with alloys of the W-carbide group.

(4626) Chromizing and Chromizing Combined with Calorizing of Tubular Products. M. K. Shelud'ko, *Stal, 7,* No. 6, 519-523 (1947). Data on improved chromizing process used in author's study. Composition of chromizing compound; chromizing temperature and time; case thicknesses obtained. Tests on different lots of chromized tubes destined for use in ships, condensers, exhaust pipe, and nitric acid installations. Chromizing combined with aluminizing for increased heat resistance. Steel tubes so treated and results of tests for heat resistance.

(4627) Coatings of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3773/47 (1947). Unsuccessful experiments to obtain WC coatings on iron from tungsten hexacarbonyl in a carburizing atmosphere, as claimed in a Sw. Patent 186,611 by C. Trenzen, are described in this report dating from 1937.

(4628) Properties of Hard-Facing Alloys. Studiengesellschaft Hartmetall. F. D. Rept. No. 3879/47 (1947). Krupp hard-facing alloys were found in 1941 to have very low resistance to HCl or HNO_3 at room temperature. Very inferior to hard metal compositions.

(4629) Coating of Aluminum. Studiengesellschaft Hartmetall. F. D. Rept. No. 3899/47 (1947). Unsuccessful experiments in 1934 to confirm a Patent Application by B. Berghaus to coat aluminum with nickel from the carbonyl, into which WC powder was then to be sintered.

(4630) Cladding of Iron Sheets. Studiengesellschaft Hartmetall. F. D. Rept. No. 3912/47 (1947). Calipers were made in 1942 by cladding iron sheet with tungsten or molybdenum foil, coating with lampblack, and heating for several hours at 1100° C. (2010° F.). Any pores could be closed by impregnating the carbide layer with copper or silver.

(4631) Hard Metal Coatings. Studiengesellschaft Hartmetall. F. D. Rept. No. 3927/47 (1947). Hard metal coatings of up to 0.1 mm. thickness can be obtained either by carburizing tungsten or molybdenum sheet or by sintering a carbide layer on such sheet and impregnating with molten copper, silver, etc. The carburizing experiments of 1942 are summarized.

(4632) Hard-Facing Bodies. Studiengesellschaft Hartmetall. F. D. Rept. No. 3971/47 (1947). Hard-facing with WC bonded with Fe-FeMn is described in report of 1945.

(4633) Corrosion of Iron under Protective Coating. J. K. Wirth, *Arch. Metallkunde, 1,* 452 (1947). Dry powdered Pb- or Zn-base pigments displayed strong positive charge; when applied in linseed oil the charge was negative; this was checked by contact with basic and acid tar dyes.

(4634) Smears of Titanium Metal. W. A. Wooster, and G. L. Macdonald, *Nature, 160,* 260-262 (1947). Friction produced by drawing metallic Ti firmly across many substances harder than it, is sufficient to produce chemical interaction in which the metal is deposited as a silvery surface film.

(4635) Metal Spraying. *Argus, Ind. Finishing,* 132-35 (1948). A practical account of the respective advantages and disadvantages of the powder and wire pistols.

(4636) Electrodeposition of Tungsten Alloys. *Corrosion and Material Protection, 5,* No. 2, 10, 17 (1948). Of the alloys investigated by the National Bureau of Standards, cobalt-tungsten was found to deposit most easily; in some properties it resembles Stellite, and appears suitable as a hard-facing element.

(4637) New High Alloy Hard-Facing Materials for Automatic Arc Welding. *Materials and Methods, 27,* No. 3, 78-79 (1948). The new filler rods consist of steel tubing containing the various alloying elements in granular form; the method of fabricating permits variation in analysis to meet specific conditions.

(4638) W. E. Ballard, *Metal Spraying and Sprayed Metal.* Based on Editions by E. C. Rollason, T. H. Turner, and N. F. Budgen, Griffin, London, 1948, 362 pp. Material added on modern powder process, metal spraying techniques, preparation of surfaces, special processes, properties of metal sprayed surfaces.

(4639) Hard Facing Improves Tool Life. L. Barrett, *Am. Machinist, 92,* No. 8, 94-95 (1948). Application of hard facing material by metal spray and subsequent fusion can increase the performance of friction surfaces up to 14 times that of the original material.

(4640) Chromizing Steel Surfaces. G. Black, and E. Rosen, *Metal Finishing, 46,* No. 8, 70 (1948). Articles packed into steel retort with a porcelain mass charged with $CrCl_2$, sealed and heated for 5 hrs. at 565° C. (1000° F.). Cr atoms deposit on and diffuse into the surface of steel; the concentration of Cr at the surface is 35-40%. The steel contains 0.06% C and 0.5% Ti which forms Ti carbide in the grains instead of at the boundaries.

(4641) Powder Welding. C. B. Clason, *Welding Engr., 33,* No. 2, 60-62 (1948). Metal powders, rubber and enamels can be flame applied with a controlled atmosphere. The materials and the equipment are described.

(4642) Selection of Protective Coating for Metals. K. G. Compton, *Corrosion, 4,* No. 3, 112-114 (1948). Various types of coatings are discussed; Zn, Cd, providing cathodic protection at pores; surface reaction treatment with phosphates improves the performance; Ni, Sn, Cu, Cr must be built up to a point where the porosity is diminished.

(4643) Metal Coating by High Vacuum Evaporation. P. Godley, *Iron Age, 161,* No. 14, 90-91 (1948). Fundamental aspects of evaporated coating units for continuous and batch type work. Physical characteristics of such coatings and applications are discussed.

(4644) Flame Spraying of Dust Extraction and Ventilation Plant. H. W. Greenwood, *Sheet Metal Inds., 25,* No. 253, 975-7 (1948). Using the Schori process in producing coatings of either metal or plastics on fan blades, casings, ducts or trunkings; also inside of dust precipitation and separating plant; methods of ventilation.

(4645) Chromium Impregnation. F. C. Kelley, *Metals Handbook.* Am. Soc. Metals, Cleveland, 1948, pp. 705-06. A discussion of chromizing is given, including methods, atmosphere, furnace, materials used, structure of coating, diffusion rates, resistance to corrosion and applications.

(4646) Hard Surfacing with High Frequency Currents. E. M. Kouzmak, and A. T. Kourolin, *Eng. Digest, English Ed., 9,* 258-61 (1948). The method of depositing hard alloys by high frequency welding promises to give good results in connection with drills for oil wells.

(4647) Plating Molybdenum and Tungsten by Thermal Decomposition of their Carbonyls. J. J. Lander, and L. H. Germer, *Trans. Am. Inst. Mining Met. Engrs., 175,* 648-892 (1948). Magnetron rings were plated with Mo, W, and Co for test purposes.

(4648) Preparing Surfaces for Metallizing. R. Mansell, *Steel, 122,* No. 9, 93-94 (1948). To insure that coating will adhere permanently, blasting, rough threading or electric bonding methods are used to clean and roughen surfaces for metal spraying.

(4649) Carburization of Tungstenized and Molybdenized Iron. M. Niessner, *Met. Powd. Rept., 2,* No. 12, 187 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 196 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 45. Using F. Halla's method of producing W or Mo coatings on Fe by H reduction of molten sodium tungstate or molybdate, it was found that carburizing with propane/butane in H increased the surface hardness by 120% and 90%, respectively.

(4650) Plating Chromium by Thermal Decomposition of Chromium Hexacarbonyl. B. B. Owen and R. T. Webber, *Trans. Am. Inst. Mining Met. Engrs., 175,* 693-698

(1948). Chromium was deposited at a rate of 0.001 to 0.002 in. per hour on steel in the presence of hydrogen. Temperatures near 450 and 625° C. (840 and 1160° F.) gave the most satisfactory bond between the chromium coating and the steel disks. The coatings deposited at the higher temperature were extremely hard (2000 Vickers) and contained not more than 40% Cr, balance Cr_2O_3 and Cr_3C_2; the coatings deposited at the lower temperature were softer (1200 Vickers) and contained 95% Cr, balance Cr_2O_3.

(4651) Deposition of Tantalum and Columbium from Their Halides. C. F. Powell, I. E. Campbell and B. W. Gonser, *J. Electrochem. Soc., 93,* 258 (1948). The general conditions for ductile, non-porous coatings of Ta and Cb by H reduction of $TaCl_5$ and $CbCl_5$ are discussed. Deposits up to 0.76 mm. thickness obtained on Cu, Fe, Ni, Mo.

(4652) Metal Spraying Guns. J. Püschel, *Werkstatt u. Betrieb, 81,* No. 3, 69-70 (1948). Metal spraying methods and equipment, and fields of application are described.

(4653) Guns for Metal Spraying. H. Reiniger, *Metalloberfläche, 2,* No. 1, 1-12 (1948). Guns for liquid metal; guns for metal powder; guns for metal wires; electrical guns.

(4654) Texture of Sprayed Metal Coatings. H. Reiniger, *Metalloberfläche, 2,* No. 5/6, 97-111 (1948). Production and composition of metal coatings; the transition to the base metal; the preparation of base material; the finishing.

(4655) Hard Facing. L. Sanderson, *Machinery Lloyd, 20,* No. 19, 75-79 (1948). Materials for hard facing are discussed; among others are solid tungsten carbide and crushed tungsten carbide.

(4656) The Pyrolytic Plating of Copper, Iron or Steel with Molybdenum, Tungsten, Chromium. E. R. Thews, *Metalloberfläche, 2,* No. 9, 193-4 (1948). The plating is accomplished by reacting the metals to gaseous carbonyl compounds and subsequently decomposing the carbonyls to metal and carbon oxides on the surfaces of the base metals.

(4657) Sprayed Metal Coatings. J. E. Wakefield, *Metal Progress, 54,* No. 6, 827-32 (1948). Characteristics of sprayed Al, Zn, Sn, Cu, Ni, Fe, brasses, bronzes and steel.

(4658) Vapor-Phase Deposition of Refractory Metals. I. E. Campbell, C. F. Powell, D. H. Nowicki, and B. W. Gonser, *Iron Age, 163,* No. 24, 98-100 (1949). Vapor-deposition processes can be used to deposit coatings of the most refractory metals at temperatures far below the melting point. A table gives data for vapor-deposited coatings and their properties.

(4659) Electro-Metallizing Techniques. T. A. Dickinson, *Ceram. Age, 54,* No. 4, 204-6 (1949). Description of "cathode sputtering" and "evaporation coating," two unusual, yet related, processes introduced in Los Angeles, Calif., area, for use in applying both transparent and opaque metal coatings to glass and other ceramic product surfaces; at present time both techniques are relatively expensive and should be considered as substitutes for other metallizing methods only when latter are inadequate from commercial or scientific viewpoint.

(4660) Hard-Facing Takes to Powder. L. B. Holtgreen, and R. E. Parker, *Welding Eng., 34,* No. 1, 40-43 (1949). Though the powder is applied by a metallizing gun, the process must not be confused with metallizing. The difference is that the sprayed deposit is fused to the base metal at 1038° C. (1900° F.) with a torch, producing a molecular bond.

(4661) Metal Spraying Costs. L. E. Kunkler, *Welding Engr., 34,* No. 12, 28-9 (1949). Contains average data on costs per hour for labor, gases and maintenance of the pistol; the weights of different metals that can be sprayed per hour; coating thickness per lb. sprayed metal.

(4662) Flame Spraying of Metals and Plastics in Engineering and Shipbuilding. F. A. Rivett, *Inst. Eng. Ship-Builders, Scotland, 92,* Pt. 6, 331-354 (1949). Metal spraying is being increasingly applied to marine installations, *e.g.*, main tanks of submarines, hulls of launches, rudders.

(4663) Metal Spraying. M. J. Rowan, *Machinist (London), 93,* 775-86 (1949). A review article with diagrams showing the technique of building up worn parts,

correct and incorrect methods of surface preparation, the range of spraying materials and their application.

F. Addition agents and coatings for non-metal bases (glass, ceramics, stones, refractories, cement, asbestos, rubber, paper, fabrics, wood, oils and organics)

(4664) The Impression of Metallic Powders on Cotton Cloth. J. Frossard, and C. Rebert, *Soc. Ind. Mulhouse Bull., 87,* 284-6 (1921). Metal impregnation techniques for fabrics described.

(4665) Zinc Dust. L. Kollmann, *Melliand Textilber., 9,* 1008 (1928). Use of zinc dust in discharge printing.

(4666) Pulverized Iron for Water-Proofing Floors and Walls. C. Kew, *Creamery & Milk Plant Monthly, 20,* No. 5, 90-1 (1931). Describes use. The iron powder is mixed with water and applied with a brush on the walls or floors to make them waterproof. Water soaks into wall, carrying along the iron particles; when they rust they swell up to several times their former size and seal the pores.

(4667) Compounding of Aluminum Powder with Rubber. W. D. Guppy, *Inst. Rub. Ind. Trans., 8,* No. 2, 131-5 (1932). The effect of increasing additions of aluminum powder on the properties of vulcanized rubber was investigated. The physical properties of the powder were tested by determining its settling power in benzene.

(4668) Aluminum Coatings for Sand Cores. M. Desplats, *Assoc. Tech. Found. Bull., 8,* 532 (1934). Core dressings of linseed oil containing aluminum powder.

(4669) Aluminum. *Municipal Journal (London), 44,* 397 (1935). Use of powdered Al in road surfacing described.

(4670) Aluminum Powder for Waterproofing Fabrics. C. H. S. Tupholme, *Ind. Eng. Chem., News Ed., 13,* 166 (1935). British patent 414,212 is discussed.

(4671) A New Inorganic Cement and Adhesive. D. S. Hubbell, *Ind. Eng. Chem., Ind. Ed., 29,* No. 2, 123-132 (1937). Cu powder is used as constituent in Mg-oxychloride cements.

(4672) The Application of Aluminum Powder to the Preservation of Vulcanized Rubber. T. R. Dawson, *J. Rubber Res. (London), 7,* 95-108 (1938). Powder applied to rubber by actual mixture in the stock; by dusting on surface of partially vulcanized slabs, and then completing vulcanization by suspending Al in benzene-rubber solution and painting the slabs with the suspension.

(4673) Metal Paper. W. Lange, *Chem. Z., 109,* II, 4148 (1938). Review of impregnation, printing, lacquering and application of metallized papers.

(4674) Copper Powder in Magnesium Oxychloride Cements. P. Buck, *Sands, Clays & Minerals, 3,* No. 4, 316-17 (1939). Such additions made to cement which normally expands in setting cause instead a slight shrinkage; the resistance to water is increased.

(4675) Aluminum Powder. J. F. McMahon, *Brick & Clay Rec., 95,* No. 5, 58 (1939). Aluminum powder additions improve strength of silicon carbide and graphite powder. Bodies for tests having the lowest absorption were mixed from 15% clay, 15% Al, 70% SiC.

(4676) Use of Aluminum Metal in the Ceramic Industries. H. G. Schurecht, and H. I. Sephton, *J. Am. Cer. Soc., 23,* 259-64 (1940). Properties of refractories produced with mixtures of powdered aluminum, fire clay and grog.

(4677) Use of Iron Powder for the Grouting of Magnetic Brick. H. Stuetzel, *Stahl u. Eisen, 60,* 1061 (1940). Laboratory experiments on usefulness of 7 mixtures of various Fe powder with water or organic binders.

(4678) Aluminum in Concrete. F. R. McMillan, *J. Am. Concrete Inst., 13,* 183-4 (1941). Aluminum powder to increase bond of concrete to reinforcing steel.

(4679) Job Problems and Practice. *J. Am. Concrete Inst., 13,* No. 3, 273-82 (1942). Series of notes include effect of aluminum powder on durability of concrete. The most striking results are obtained by first intergrinding very fine Al with sand, and adding enough to cause several per cent of voids.

(4680) Powdered Aluminum as Admixture to Concrete. R. W. Carlson, *Proc. A.S.T.M., 42,* 808-18, 819-20 (1942). To increase resistance to freezing and thawing in calcium chloride, improve bond strength to steel and greater flexural strength.

(4681) Metal-Ceramics. F. Reinhart, *Keramische Rundschau, 50,* 121-123 (1942). A comprehensive review of the subject is given.

(4682) High Refractory Sintered Oxides. G. Jaeger, *Z. Ver. deut. Ing., 89,* No. 1, 19-22 (1945). Properties of oxide-ceramic materials; sintered oxide-ceramic products and their production. Metal additions and impurities broached.

(4683) Deposition of Metals as Coatings, Especially by Decomposition of Carbonyls, from Gaseous Phase. H. Borchers, U.S. Dept. Comm. PB. 14956/1945, 5 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 22, 1339 (1948). Production of metallic coatings; metallizing of delicate organic fibers without damage by lowering the decomposition point of the carbonyls.

(4684) Alloys and Ceramic Materials for High-Temperature Services. H. C. Cross, Symposium on Materials for Gas Turbines, Am. Soc. Testing Matls., 1946, pp. 113-20. Includes discussion of metal-ceramic combinations employing metal powders.

(4685) New Ceramic-Combines: Ceramic Materials and Metal Powders. H. H. Hausner, *Ceramic Industry, 47,* No. 11, 87, 90 (1946). According to the process of combining ceramic materials with metal powders, such properties as magnetism, electric conductivity, heat conductivity and hardness can be incorporated into ceramic products. Comparison between physical properties of ceramic products and metal powder products.

(4686) Gas Turbine Research. S. T. Robinson, and R. S. Sproule, C. I. O. S. Rept. No. XXVII-20 (1946). M. A. N. and Professor E. Sörensen have investigated use of ceramic materials for turbine blades. Sintered alumina has tensile strength and good stability up to 1200° C. (2190° F.) but maintaining costs were excessive. Metallic additions and impurities discussed.

(4687) High Temperature Refractories and Ceramics. W. Watt, F. H. Clews, R. B. Miller, J. Walker, and C. H. Wheatley, B.I.O.S. Final Rept. No. 465 (1946). A summary of German experiments of turbine blades produced from alumina or sillimanite, but no details as to their suitability are given. Reference to combinations with metal (*e.g.*, iron) powders.

(4688) Development of H at- and Flame-Resistant Material of Low Density. J. Bingel, *Arch. Metallkunde, 1,* No. 7/8, 309-310 (1947). Two types of sintered compositions are suggested: I. 3% Cr, 6% Co, 2% W, 5% TiC, 84% SiC. II. 10% Fe, 2% TiC, 88% SiC. The sintering temperature is reduced by addition of Fe.

(4689) Metal-Ceramics. A. R. Blackburn, *Ohio State Univ., Eng. Expt. Sta. News, 19,* No. 5, 24-27 (1947). The wetting and combining of oxide ceramics such as Al_2O_3 with certain metals such as chromium are described.

(4690) Bonding Sapphire to Metal. T. C. Du Mond, *Materials and Methods, 26,* No. 4, 84-86 (1947). Sapphire can be soldered to metal parts through a new bonding process. Product used to size surfaces of powder metallurgy bearings. Composite material studied in connection with gas turbines parts.

(4691) The Electrical and Technical Ceramic Industry. Elektroschmelzwerke, A. G., F.I.A.T. Final Rept. No. 617, Nov. 1946, 141 pp.; *Met. Powd. Rept., 1,* No. 5, 78-80 (1947). Metal-ceramic combination materials such as refractory oxides mixed with iron, other metals, alloys and carbides, produced by hot pressing, were experimentally developed for turbine blade application in Germany during the war.

(4692) Investigation of Pure Oxide Ceramic Materials for High Temperature and High Stress Applications. F. O. Hess, F.I.A.T. Rept. No. 924 (1947). This

report highlights the properties of sintered refractory oxides and their manufacture. Reference to metallic additions made.

(4693) Joining Ceramics and Metals by Soldering. E. D. Reed, *Materials and Methods, 26,* No. 1, 126 (1947). Ceramic parts were made of talcum or Mg-silicate, mixed with China clay, Zr-dioxide, potassium feldspar, coated with Mo-Fe particles and then with Ni powder solution.

(4694) Sintered Materials from Mixtures of Metals and Non-Metallic Materials. F. Skaupy, *Arch. Metallkunde, 1,* No. 7/8, 307-308 (1947). Metal-ceramic mixture can be tackled only now that powder metallurgy has achieved a certain stage of development. Distinction is made between products in which either metal or oxide predominates.

(4695) Mixed Bodies of Metals and Non-Conductive Materials. F. Skaupy, *Die Technik, 2,* 157-8 (1947). Examples for materials of metals and metal-oxides are given, also their uses for high working temperature.

(4696) Bonding Alumina in Steel. R. Skorski, U. S. Dept. Comm. PB. 20664, (1947). Some aspects of German work on high temperature materials are mainly concerned with ceramic turbine blade materials. Meyer-Hartwig developed a method for bonding alumina to steel by sintering a layer of iron powder between them.

(4697) "Cermets"; Ceramic Metal Compounds. *Ceramic Ind., 51,* No. 3, 108 (1948). New compounds that give promise as a material in jet engines and rockets. They include oxides and metal combinations; mixtures of oxides, carbides, nitrides, borides and silicides.

(4698) Metals and Ceramics. Wide Industrial Possibilities of Coatings. *Chemical Age, 59,* No. 1518, 219-220 (1948). The Ohio State University gave three papers on steel coated with sintered 75:25 Ni-magnesia which was either applied as a paint with sodium silicate as a vehicle or flame-sprayed. Resistance to thermal shock by addition of metal powders to ceramics. Metal-bonded ceramics ("Cermets") for high temperature applications are briefly reviewed.

(4699) Magnetic Fluid Clutch. *Natl. Bur. Standards, Tech. News Bull., 32,* No. 5, 54-60 (1948). J. Rabinow discovered that a suspension of magnetic particles in oil, when interposed between two magnetic surfaces, could bridge the surfaces with a firmness depending linearly upon the magnitude of the induced magnetism.

(4700) "Cermets". G. A. Bole, *Eng. Expt. Station News (Ohio State Univ.), 20,* 26-27 (1948). Production, properties, techniques and processes for ceramic-metal composition are described.

(4701) Ceramic Materials for High Temperature Service. J. R. Bressman, *Materials & Metals, 27,* No. 1, 65 (1948). Requirements for high temperature service are reviewed together with the materials and their properties, forming and fabricating ceramic parts, refractory coatings for metals, and mixtures of ceramics and metals.

(4702) Magnetizable Paper. T. C. DuMond, *Materials and Methods, 27,* No. 6, 220 (1948). At the Chicago Tribune, the classified advertising section is made by typing on paper backed with a coating of fine iron powder. The advertisements are then cut up and pasted on magnetized make-up boards.

(4703) Ceramics-Silicon Ceramics-Metal Ceramics. M. Hauser, and F. Held, *Met. Powd. Rept., 2,* No. 12, 179; *Oesterr. Chem. Ztg., 49,* No. 10/11, 196-197 (1948). Intern. Powder Metallurgy Conference Graz, Ref. No. 49. Authors conclude that it seems to be of little influence on the quality of the end product whether the iron is included as metal powder or powdered oxide, provided the water of hydration in the clay is driven out completely, giving oxidizing conditions before sintering.

(4704) Sintered Semiconductors. H. H. Hausner, *Electronics, 21,* 138 (1948). Production and principles of ceramic-metal compositions. Results of investigations of effect of particle size and distribution and sintering temperature.

(4705) Metal Ceramics. H. H. Hausner, *Metal Ind. (N.Y.), 72,* No. 20, 405-7 (1948). Function of metal powders within "ceramals," combinations or mixtures of ceramic materials and metallic powders. Application as electric resistor material; development in field of high temperature resisting materials. A table of melting points of some metals, their oxides and their silicates.

(4706) Metal Ceramics. H. H. Hausner, *Proc. Fourth Ann. Spring Meeting Met. Powd. Assoc.*, Chicago, Apr. 15-16, 1948, pp. 19-28. Electrical properties of ZrO_2–Fe_2O_3–Cu and TiO_2–Ni compositions discussed, including melting points of some metals, their oxides and their silicates. Physical properties of sintered alumina. Electric capacitors.

(4707) Metallurgy Research Drives to Meet New Economic Needs. E. S. Kopecki, *Iron Age, 161,* No. 1, 198 (1948). Refers among other matters to metal-ceramic combinations; porous ceramic compacts infiltrated under pressure with molten metal; fundamental study of reactions between metals and ceramic oxides or carbides at high temperatures; investigation of properties obtained by combining ceramics and metals.

(4708) Studies on Semi-Metals with Continuously Varying Properties. E. Meyer-Hartwig, *Met. Powd. Rept., 2,* No. 12, 180; *Oesterr. Chem. Ztg., 49,* No. 10/11, 197 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 21. Semi-metals are metal-metal oxide mixtures, and their mechanical properties are dependent on the mixture of the powders. The conception of capillary semi-conductors is explained.

(4709) Ceramic Coatings for Molybdenum at High Temperatures. D. C. Moore, L. H. Bolz, and W. N. Harrison, *Ceramic Age, 52,* No. 5, 312-13 (1948). Condensed version of National Advisory Committee for Aeronautics, *Tech. Note No. 1626* (1948). Ceramic-coated Mo was used as pilot tube for recording pressure in the 1650° C. (3000° F.) blast of a ram-jet engine.

(4710) Material and Design Problems of Steam and Gas Turbines. H. Niermeyer, *Arch. Metallkunde, 2,* No. 5, 145-54 (1948). Study of heat resisting materials; relation between material, construction, shape and quality; effects of temperature, creep and vibrations; characteristics and use of ceramic and metal-ceramic materials; limitations. Bibliography.

(4711) E. Ryschkewitsch, *Oxydkeramik,* Springer, Berlin, 1948, 280 pp. Treatment of fundamentals; comminution, plastic deformability, burning cycles, and discussion of the physical chemistry of the single phase systems of alumina, spinel, magnesia, beryllia, zirconia, thoria and ceria.

(4712) Electroplating on Non-Conductors. A. H. Stuart, *Electroplating, 1,* No. 5, 187-91 (1948). Use of metallic powders and silver films; advantages of colloidal graphite; plating bath essentials.

(4713) Magnetic Fluid Uses. *Electronics, 22,* No. 9, 120 (1949). The composition of the ferromagnetic powder containing fluids (oils) and their uses are described.

(4714) A Servo Employing the Magnetic Fluid Clutch. E. S. Bettis, and E. R. Mann, *Rev. Sci. Instruments, 20,* 97-101 (1949). A simple experimental unit was built, with a 3:1 suspension of carbonyl iron in oil. The theory and the performance of the clutch are given.

(4715) Metal-Ceramic Materials for Application in the Design of Jet-Propelled Devices. A. R. Blackburn, *Ohio State Univ. Res. Foundation Rept., 13,* 1949, 5 pp. Metal-bonded ceramic bodies are discussed, with reference to silicon carbide and alumina as ceramics and nickel and chromium as metals.

(4716) Fundamental Study, and Equipment for Sintering and Testing of "Cermet" Bodies. A. R. Blackburn, I. S. Shevlin, and H. R. Lowers, *J. Am. Cer. Soc., 32,* No. 3, 81-98 (1949). Development of "cermet" bodies, composed of metals and oxides, for high temperature service; theoretical aspects of experiments of fundamental chemistry nature which accompanied laboratory development of test specimens; wetting of alumina by nickel, cobalt, iron, chromium, and chromium-boron; furnace equipment for "cermet" fabrication.

(4717) Clutches: Characteristics and Design of Magnetic Fluid Types. R. S. Elberty, *Machine Design, 21,* No. 5, 98-102 (1949). Gives torque calculations and diagrams.

(4718) New Materials Lengthen Life of Jets and Rockets. D. W. Grobecker, *Metals Rev., 22,* No. 1, 11 (1949). A report on the development of metal-ceramic mixtures to combine resistance to high temperatures and thermal shock.

(4719) Silicon-Base Ceramics and Ceramic-Metals. M. Hauser, *Schweiz. elektrotech. Ver. Bull., 40,* No. 12, 208-15 (1949). Refers to the production of apparatus and vessels for the chemical industry from materials made from ceramics mixed with metal powders.

(4720) Metal-Ceramic Materials for Application in the Design of Jet-Propelled Devices. E. T. Montgomery, *Ohio State Univ. Res. Foundation Rept., 18,* 4 pp. (1949). A survey of work done on metal-bonded solid ceramic bodies; protection from oxidation afforded ingot iron sheets coated by metal-bonded ceramic grain coatings.

(4721) Magnetic Fluid Clutch in Servo Applications. G. R. Nelson, *Electronics, 22,* No. 11, 100-03 (1949). Describes various tests made on a 3-in. unit and its application in an electronic multiplying device.

(4722) Ceramic Research and Developments as Related to Aircraft Power Plants. E. L. Olcott, *Technical Data Digest, 14,* No. 5, 15-18 (1949). Metallo-ceramics and reinforcement of ceramics are discussed.

(4723) Ceramic Materials as Substitutes for Metals. F. Reinhart, *Z. Ver. deut. Ing., 91,* No. 14, 341-3 (1949). Review of various applications in cooking and tableware, water heaters, hard porcelain pipe, products with metal admixtures (powder metallurgy), moving machinery parts, and ceramic machines and apparatus.

(4724) Characteristics of Materials Involved in Magnetic Fluid Clutch. H. D. Saunderson, *Proc. Fifth Ann. Spring Meeting, Met. Powd. Assoc.,* Chicago, Apr. 5-6, 1949, 93-105. Some of the characteristics will be dependent upon the powder and others upon the vehicle.

(4725) Fundamental Study, and Equipment for Sintering and Testing of Cermet Bodies. Developing and Testing Equipment. T. S. Shevlin, and A. R. Blackburn, *J. Am. Ceram. Soc., 32,* No. 11, 363-6 (1949). Relatively large molybdenum wound resistor furnace, diamond wheel rod grinding and tensile stress rupture machines, and thermal expansion equipment used for development and testing of cermets are described; all are additions to equipment described previously, having been designed and used successfully during past year.

G. Paints, pigments and inks

(4726) Developments in Bronze Color Manufacture. E. Odernheimer, *J. Soc. Chem. Ind., 15,* No. 4, 283-4 (1896). Bismuth-aluminum-bronze powder. Improvement in bronzing apparatus. Bronze substitutes.

(4727) Metal Powder Paint Tests. H. A. Gardner, *Paint Mfrs. Assoc. U.S., Circ. No. 130,* July 1921, 12 pp. Due to the fact that uniform results were obtained with raw linseed oil its use is suggested as a medium for Al powder.

(4728) Zinc Dust. J. M. Matthews, *Color Trade J., 10,* 14-16, 58-61, 112-3, 144-5 (1922). Its uses in the manufacture and application of dyestuffs described.

(4729) Zinc Dust. J. M. Matthews, *Color Trade J., 10,* 252 (1922). Use in white discharge printing.

(4730) Zinc Dust. J. M. Matthews, *Color Trade J., 11,* 9 (1922). Use in colored discharge printing.

(4731) Zinc Dust. E. Cagliostro, *Color Trade J., 12,* 27-8 (1923). Use in wool printing.

(4732) Zinc Dust. B. De Puyster, *Color Trade J., 12,* 133-4 (1923). Use in silk printing.

(4733) Zinc Dust. B. De Puyster, *Color Trade J., 13,* 38-50, 160-1 (1923). Use in dyeing with synthetic indigo.

(4734) Manufacture of High Grade Aluminum and Bronze Powders. O. Smalley, *Metal Ind. (London), 24,* 273-74, 297-98, 445-46, 493-94, 569-70; *25,* 169-70, 369-71 (1924). The following is covered: Bessemer's experiments; loss of

industry to Germany; effects of impurities on color; treatment of scraps; the function of grease; best qualities and types of lubricant; disintegration and color consideration; polishing; grading the finished powder; and dyeing of aluminum powder.

(4735) Zinc and Aluminum Powder Paint Tests. H. A. Gardner, *Paint Mfrs. Assoc. U.S., Circ. No. 231,* Apr. 1925, 222-47. The use of small amounts of metal powder in white paints to deter the weathering effect.

(4736) Manufacture of High Grade Aluminum and Bronze Powders. O. Smalley, *Metal Ind. (London), 27,* 1-2, 93-94, 185-86, 283-84, 575-76 (1925). Gold (brass) and bronze powders; selection of grease and polishing; coloring; recent advances in manufacture and uses of powders.

(4737) H. A. Nelson, and W. A. McKim, *Metallic Zinc Powder as Paint Pigment.* New Jersey Zinc Co., New York, 1926, 26 pp. Review.

(4738) Zinc Dust. J. Richter, *Chemicals, 25,* 19-20 (1926). Use in dyeing synthetic Indigo.

(4739) Bronze Colors and Gold-Leaf Alloys. *Farben-Ztg., 32,* No. 31, 1732-3 (1927). The non-genuine gold-leaf produced of Cu-Zn alloys must have the same ductility as genuine gold-leaves, otherwise the leaves spall during the impact tensile stresses imposed during stamping; therefore the alloy must contain 9-17% Zn.

(4740) J. D. Edwards, *Aluminum Bronze Powder and Aluminum Paint.* Chemical Catalog Co., New York, 1927, 104 pp. Manufacture of aluminum bronze powder; properties, examination; Al paint, properties and uses.

(4741) Zinc Dust. *Melliand Textilber., 9,* 1008-12 (1928). Use in discharge printing of textiles.

(4742) Aluminum Powder for Paints. British Engineering Standards Association, Brit. Standards Spec. No. 388, 1930, 6 pp. Composition, copper content, and settling properties are discussed.

(4743) Printing with Metallic Powders. R. Sansone, *Textile World, 78,* 190-1 (1930). A description of method employed is given.

(4744) Aluminum as Protective Paint. P. Urech, *Schweiz Tech. Z., 29,* 614-6 (1932). Processing and testing of Al-bronze as protective paint pigment.

(4745) Printing with Metallic Powders. *Melliand. Textilber., 5,* 168-9 (1933). A review of the process is given.

(4746) Aluminum Powders and Aluminum Paints. F. Friedrich, *Metallbörse, 24,* No. 11, 162-63; No. 13, 194-95 (1934). Advantages of Al paints are their high grade of covering power, their opaqueness, and their high reflecting power.

(4747) Aluminum Bronze Powder and Its Importance As Coating for Surface Protection. F. Kolke, *Oberflächentechn., 11,* 113-4 (1934). A brief survey of the use of the powder in paints is given.

(4748) Titanium Pigments for Gloss Finishes. D. W. Robertson, *Federation of Paint & Varnish Clubs, Off. Dig.* No. 134, 67-72 (1934). In the case of modern white opaque gloss finishes titanium has become the dominant ingredient in white pigment. Three types of Ti pigments lend themselves to a further means of body control.

(4749) Aluminum Bronze as Coating Material. K. Vnuk, *Chem. Obzor, 9,* 7-9, 30-2 (1934). Manufacture of Al-bronze and properties of Al-bronze paints and coatings are described.

(4750) Aluminum Powder as a Metal Finish. J. C. Chaston, *Aluminum and Non-Ferrous Rev., 1,* 19-20 (1935). Uses in paints and pigments described.

(4751) Coal-Resin Paint and Its Application in the Chemical Industries; Association of Resin with Aluminum Powder. F. Delarozière, *Rev. prod. chim., 38,* No. 23, 710-11, 741-3 (1935). Description of preparation of tar and paint is given.

(4752) Aluminum-Powder Paints. T. Freitag, *Z. Oberflächentechn., 12,* 152-3 (1935). Aluminum powder and paint vehicle should be mixed only a short time before use.

(4753) Aluminum Paints and Protection of Iron. J. Roux, *Recherches et inventions, 16,* 228 (1935). Discussion shows the efficient protection afforded by aluminum-coal-tar pitch paints.

(4754) Synthetic Vehicles and Zinc Paints. *Steel, 98,* No. 16, 46 (1936). The synthetic vehicles have produced a harder film which does not flow as readily as natural vehicles.

(4755) J. D. Edwards, *Aluminum Paint and Powder,* Reinhold, New York, 1936, 216 pp. Manufacture of aluminum powder; properties. Composition of aluminum paint. Al paint in protection of metals, and in protection of wood.

(4756) Zinc Powder Use in Dyes. H. Peters, *Textile Colorist, 58,* 826 (1936). Special reference is made to Zn powders used in the reducing vat for dyes.

(4757) Aluminum Powder and Its Practical Applications. V. Oskarson, *Tek. Tid., Uppl. C. Kemi, 67,* 33-37 (1937). Various industrial applications are discussed, mainly in pigment industry.

(4758) Metallic Paints. G. Sverige, *Peintures-Pigments-Vernis, 14,* No. 9, 188-9 (1937). Bronze powder paints are listed according their composition.

(4759) Tentative Specifications for Aluminum Powder for Paints. *Proc. A.S.T.M.,* D266-38T, *38,* Pt. 1, 821-5 (1938). Type A: Standard fineness for general paint use; type B: Extra fine for special use.

(4760) Lacquer Printing on Silk and Rayon. C. Frey, *Am. Dyestuff Reptr., 27,* P 103-6 (1938). Use of bronze powder in pigment.

(4761) E. Stock, *Farben-Ztg., 43,* No. 13, 333 (1938). Bronze powders employed in paints including Al paints are described. The finished color in containers was tenable during several months; the precipitated metal could be stirred easily.

(4762) Aluminum Powder. *Light Metals, 2,* No. 14, 94 (1939). Use of Al powder as pigments for paints is described.

(4763) Zinc-Dust Paints for Improved Maintenance of Metal Surfaces. *Steel, 104,* No. 17, 42-43 (1939). Due to a galvanic action the zinc dust paints deter rust formation on iron or steel surfaces.

(4764) Aluminum Powder for Paints, Specification D266-39. Am. Soc. Testing Matls., *A.S.T.M. Standards, 1939, Part II,* 1939, p. 596. The specification reads in part that the Al powder used for paints shall consist of fine polished flakes and be free of filler. The polishing lubricant shall not exceed 3% by weight of the metal powder.

(4765) Leafing of Aluminum Pigments. E. L. McMahan, R. I. Wray, and J. D. Edwards, *Ind. Eng. Chem., Ind. Ed., 31,* 729-33 (1939). A presentation of the study of factors involved in the measurement of leafing by the so-called spatula method. Also included is a variety of observations on the effect of various factors on the leafing of Al pigment under different conditions of application.

(4766) Modern Rust-Preventing Paints. F. Ohl, *Oberflächentechn., 16,* 131-33 (1939). Includes discussion of bronze powder. Al-Si alloy powders have shown an excellent corrosion resistance.

(4767) Mixing Vehicles and Metallic Powders. *Metal Finishing, 38,* 618 (1940). Directions for the mixing of metal powders and pastes into vehicles to assure smoother films and an easier application.

(4768) Calculations on Mixing Aluminum Finishing Materials. J. G. Shelton, *Metal Finishing, 39,* No. 8, 454-6 (1941). Refers to Al-pigments.

(4769) Bronze Pigments. H. H. Mandle, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 10, pp. 132-136; also *Metal Progress, 41,* No. 2, 214-16 (1942). Raw materials, stamping, polishing, classification, shape of flakes, power requirements, ball milling discussed.

(4770) J. J. Mattiello, *Protective and Decorative Coatings.* Wiley, New York, 1942, 658 pp. Vol. 2, Chaps. 24-27. Raw materials, pigments, metallic powders for paints.

(4771) Floating Properties of Aluminum Bronze Powders. H. T. Mayer, *Farben-Chem., 13,* No. 5, 83-85 (1942). Experiments with different solvents were made to determine the causes and remedies for the floating effects displayed by bronze powder particles in pigments.

(4772) **Aluminum Paint.** *Canad. Metals, Met. Inds., 9,* No. 6, 46 (1946). A new paint developed by the United Gilsonite Labs., Scranton, Pa., is processed from an asphalt base fortified with pure Al paste.

(4773) **Ultra-fine Pigment Particles Basis of New Lacquer.** *Chem. Inds., 59,* No. 1, 57 (1946). "Metalli-Chrome" a new lacquer made by DuPont uses Al flakes to greater effect than in the usual coatings because the extremely finely sized pigment permits deeper penetration of light rays.

(4774) **Silver Flake Paints.** A. F. Knoll, *Materials and Methods, 24,* No. 2, 425 (1946). Use of noble metal may lead to economic production in certain processes due to reduced labor costs. Silver flake powder of low apparent density used in place of Cu for some molded parts, also in paints, etc.

(4775) **Stainless Steel Powder Base Paints.** *Iron Age, 160,* No. 8, 61 (1947). Their use on fans exhausting nitric acid fumes prolonged blade life from 2 to 24 weeks.

(4776) **Use of Metallic Pigments in Protective Paints.** J. Mayne, *J. Soc. Chem. Ind., 66,* No. 3, 93-5 (1947). Cathodic protection values of Al, Mg, Zn were determined by electrical conductivity measurement of (*1*) pressed powders, (*2*) dried paint films, (*3*) measuring the electrode potential of coated steel specimens.

(4777) **Metal Powder as Pigments.** E. Scheller, *Proc. Third Ann. Spring Meeting of Metal Powder Assoc.,* New York, May 27, 1947, pp. 67-68. In the case of metallic paints, the vehicle is a varnish and the pigment is a metallic flake of bronze or aluminum. Powder can be modified by oxidation producing shades and hues. Al powder only gives one color. Stearic acid allows the flakes to remain on surface.

(4778) **Some Properties of Aluminum Flake Powder for Paints.** G. W. Wendon, *Paint Manuf., 17,* 373 (1947). Aluminum powder for use in paints should have a low rate of sedimentation with high volume. Application of non-leafing powder in paints and for pigmenting molded plastics.

(4779) **Nickel Flake Pigments.** *Paint Technol., 13,* No. 148, 136 (1948). A summary of the claims of Brit. Patent 545,962 (1942), Mond Nickel Co., for the electrolytic production of thin flake nickel pigments for paints.

(4780) **Stainless Steel Paint.** G. Black, *Materials & Methods, 27,* No. 4, 86 (1948). With the advance of stainless steel in flake and paste form the stainless steel paint is now possible for use under corrosive conditions.

(4781) **Molybdenum and Tungsten in Fancy Dress.** G. E. Hillier, *Alloy Metal Rev., 6,* No. 49, 2-6 (1948). Compounds of these metals are being increasingly applied as pigments in paint, printing inks, and for coloring rubber and plastics.

(4782) **Liquid Stainless Steel.** Charles Hardy, Inc., *Metal Powder News, 9,* No. 1 (1949). Stainless steel flake powder made by Charles Hardy, Inc., is supplied in plastic resin by Lockrey-Fater Corp. It is brushed or sprayed and is tack-free after 5 min., being fully hardened after 48 hours.

(4783) **Flake Metal Powders and Paint.** H. W. Greenwood, *Paint Manuf., 19,* 301-3 (1949). The leafing properties of flake powders confer upon the pigmented layer a high specular reflectivity, opacity, heat isolation and imperviousness to water.

H. Sundry uses and applications (drugs, insecticides, etc.)

(4784) **Powdered Iron Containing Copper and Tin.** E. Luecker, *Deut. Apoth. Ztg., 30,* 550-1 (1915). The powder is used for drugs and pharmaceuticals.

(4785) **Aluminum Dust.** *Mechanical World, 60,* No. 1541, 29 (1916). Note on various uses. Al dust is frequently adulterated with powder of Zn and Sn. Production of foil by a system of rolling and hammering; polishing of dust.

(4786) Aluminum and Zinc as Water Softeners. B. S. Srikantan, *Current Sci., 1,* 291 (1933). Al and Zn powders used.

(4787) Zinc Dust in Pharmaceutical Preparations. A. Foulon. *Wien. pharm. Wochschr., 74,* 2-3 (1941). The addition of zinc powder to various drugs and medicines is listed.

V. Theoretical Discourses

1. GENERAL PRINCIPLES OF POWDER METALLURGY
(including comparisons with fusion metallurgy)

(4788) Occurrence of Some Properties of Solid Metals Characteristic for the Liquid or Gaseous State. W. Spring, *Z. phys. Chem., 15,* 65-78 (1894); *Bull. Acad. Roy. Belg., 28,* 23-46 (1894). Alloy formation by application of heat and pressure at temperatures below the melting point of any of the various constituents.

(4789) Production of Alloys by Pressure and the Reaction Ability of Metals in the Solid State. G. Masing, *Z. anorg. Chem., 62,* 265-309 (1909). Comparison of molten alloys and pressed and sintered filings of different combinations (*e.g.*, silver alloys). Pressure alone was found not sufficient to alloy.

(4790) Synthetic Metal Bodies, Part III. F. Sauerwald, *Z. Metallkunde, 16,* 41-46 (1924). Production of synthetic metallic substances by pressure or by sintering. Tenacity, sintering temperature, elongation, grain size studied. (See also F. Sauerwald and E. Jaenichen, *Z. Elektrochem., 30,* 175-180 (1924).

(4791) Contribution to the Theory of Metallo-Ceramic Processes. M. Yu. Bal'shin, *Vestnik Metalloprom., 16,* No. 17, 87-120; No. 18, 82-91, No. 18, 91-9 (1936). I. On the theory of sintering; II. Special methods for investigation of the technology of metallo-ceramic processes; III. Principles of the rational preparation of the mixture and the problem of cementation.

(4792) Theory of Metallo-Ceramic Processes. M. Yu. Bal'shin, *Vestnik Metalloprom., 18,* No. 2, 124-37; No. 4, 89-96 (1938). IV. Theory of pressing process; V. Powder metallurgy alloys and pseudoalloys. Physical and mechanical properties of Cu-graphite, bronze, and Fe-graphites, Cu-W, etc., alloys as functions of percentage compositions, particle size of components, temperature at which prepared, etc.

(4793) Some Scientific Problems Connected with Powder Metallurgy. E. A. Báno, *Metallurgia, 23,* 51-2 (1940). General problems discussed. A reference to papers of C. Hardy, W. D. Jones, G. J. Comstock, C. G. Goetzel, G. Grube and H. Schlecht.

(4794) Powder Metallurgy. C. C. Balke, *Iron Age, 147,* No. 16, 23-27 (1941). Some important theoretical aspects related to the principles of powder metallurgy. Discussion includes reference to the metallurgy of tantalum.

(4795) Scientific and Technical Fundamentals of Powder Metallurgy and Field of Application. W. Dawihl, *Stahl u. Eisen, 61,* 909-19 (1941). Physical and chemical properties of powder metallurgical materials tabulated. Sintering properties of various materials and the effect of variables discussed.

(4796) Present Status of Powder Metallurgy. F. Sauerwald, *Metallwirtschaft, 20,* 649-55, 671-77 (1941). A review of the essential processes during the pressing and sintering. Crystallization and recrystallization. Influence of gases to the equilibrium of the structure. Transformation during sintering. Hot-pressing.

(4797) Plastic Deformation in Powder Metallurgy. C. G. Goetzel, *Powder Metallurgy*, Am. Soc. Metals, Cleveland, 1942, Chapter 7, pp. 87-108. Sintering, subsequent working, cold-pressing and hot-pressing treated. Test results shown in tabular and graphic form.

(4798) Comparison of the Properties of Sintered and Molten Metals and Alloys. R. Kieffer, and W. Hotop, *Kolloid-Z., 104,* No. 2/3, 208-23 (1943). Principles of powder metallurgy processes as compared to fusion metallurgy charted. A review with 12 tables and 27 references on density, electrical and mechanical properties of W, Mo, Ta, Cb, Ti, Zr, Th, V, Cr, U, Cu, Ag, Au, Pt, Ni, Fe, Co, steel, WC-Co, Fe-Ni, Fe-Al and Fe-Ni-Al-Cd alloys, with data both for sintered and cast or wrought materials given.

(4799) Powder Dispersoids and Their Derivatives. W. Ostwald, *Kolloid-Z., 104,* No. 2/3, 137-9 (1943). A short introduction to a symposium on powder metallurgy, giving some theoretical explanations for its principles.

(4800) Marks and Methods of Examination of the Porous State. Properties and Preparation of Porous Materials. K. E. Zimens, *Trans. Chalmers University of Technology, Gothenburg, Sweden,* No. 40, 1-178 (1944). Review with reference on the measurement of the pore volume, surface area, diffusion through capillaries, and the relation to catalytic activity. A mathematical development is given for the subject.

(4801) Principles of Powder Metallurgy. R. Girschig, *Rev. met., 42,* 178-186, 218-229 (1945). Comprehensive review of published data on the theory underlying sintering of metallic powders, on factors involved in compression and in heating for sintering.

(4802) Sintered Metals. R. Kieffer, and W. Hotop, *Metal Ind. (London), 66,* No. 22, 342-44; No. 23, 354-56; No. 24, 378-80 (1945). Comparison of properties with equivalent fused material.

(4803) Diffusion Alloying of Powders during Sintering. W. N. Pratt, *Steel, 116,* No. 1, 278 (1945). Diffusion alloying of elemental metal powders into alloys during the sintering operation for better characteristics being used extensively.

(4804) General Rules for Powder Metallurgy. H. H. Hausner, *Am. Machinist, 90,* No. 4, 104-105 (1946). 13 trend charts presented showing general trend of properties of compacted metal powders and their dependence on processing steps.

(4805) Processing Operations in Powder Metallurgy. H. H. Hausner, *Am. Machinist, 90,* No. 9, 124-125 (1946). Five methods of compacting two metal powders are compared in diagrams and step by step. Basic definitions clarify terminology.

(4806) Engineering Properties of Sintered versus Cast Metals. P. Schwarzkopf, *Product Eng., 17,* No. 2, 122-126 (1946). Selections and evaluation of powder metallurgy against conventional production methods will be facilitated by the tables given.

(4807) Engineering Properties of Sintered Metals. P. Schwarzkopf, *Product Eng., 17,* No. 4, 268-72 (1946). Information relating to three classes of sintered and pressed powder metals that can be produced only by powder metallurgy methods. Classification based on their particular properties of hardness, porosity, heat resistance, etc.

(4808) On the Strength and Plasticity of Iron Powders. I. M. Fedorchenko, *Vestnik Mashinostroeniya, 27,* No. 8, 35-42 (1947). Experimental study of the true nature of the differences in physical and mechanical properties between sintered powder metals and metals obtained by fusion. Influence of production process of powder and of density obtained in compacting upon mechanical properties of iron powder parts such as tensile properties and hardness.

(4809) Reactivity of Solids and Role in Powder Metallurgy. J. A. Hedvall, *Arch. Metallkunde, 1,* No. 7/8, 296-8 (1947). Solid solutions of Co and Ni are best and most rapidly prepared by reducing oxides in stream of hydrogen, permitting interaction of metals *in statu nascendi.*

(4810) "Construction of Alloys" as Powder Metallurgy Problem. G. Ritzau, *Arch. Metallkunde, 1,* No. 7/8, 305-307 (1947). Author reviews his work on surface chemistry of oxides, maintains that it is applicable also to powder metallurgy.

Discussion of the structure of alloys, relation between dispersion of the components and grain size, hardness and strength of alloys and composites; fibrous and "disordered" structures; and the construction of metallic materials, *e.g.*, Fe-Cu; Co-WC; Fe–Al_2O_3.

(4811) Fundamentals of Powder Metallurgy. *Metal Ind. (London), 73,* No. 12, 227, 230 (1948). The principles of the powder metallurgy processes with special reference to sintering are described.

(4812) Fundamental Similarities between Powder Metallurgy and Ceramics. K. Konopicky, *Met. Powd. Rept., 3,* No. 1, 9; *Oesterr. Chem. Ztg., 49,* No. 10/11, 178 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 32. The Rosin-Rammler law applies to all mechanically prepared powders, metal or ceramic, while atomized or electrolytic metal powders have a Gaussian distribution. With ductile metals, porosity and compacting pressure are related logarithmically. The physical properties of porous sintered metal are affected by porosity in the same sense as cast iron by graphite inclusion.

(4813) Modern Alloy Metallurgy in Theory and Practice. R. Mitsche, *Berg- u. Hüttenmänn. Jahrb., Montan. Hochschule, Leoben, 93,* 43-46 (1948). Present view on predicting and creating certain properties in alloys, transformation, nuclear action, converting of existing atom types in alloy by bombarding with protons or neutrons into other atoms.

(4814) Powder Metallurgy as Research Tool. F. N. Rhines, *Powd. Met. Bull., 3,* No. 2, 28 (1948). Mixtures of copper and nickel powders compressed and then heated in reducing atmosphere diffuse together rather slowly. At constant temperature, time is proportional to the square of the distance between adjacent Cu and Ni particles. Rate also sensitive to composition, reaching highest value at a 50:50 ratio.

(4815) Reactions of Solids and the Fundamental Principles of Powder Metallurgy. G. F. Hüttig, and H. Grubitsch, F. I. A. T. Rev. German Sci., 1939-1946; Inorganic Chemistry–VI, 80-117, 1949. A comprehensive review is given of German work, mainly of Hüttig and his school, done during 1939-1946. In an introductory survey, the properties and behavior of powders and powder aggregates are described. A second part presents the fundamental principles of powder metallurgy, including the production and properties of powder, the fritting (sintering) process, the interrelation between the chemical, physical, and mechanical properties of the sintered products and the particle size of the powders, the conditions of sintering, the presence of impurities in the powder, and the compacting pressure. The review also includes a discussion of the conditions necessary for obtaining the optimum structural characteristics and properties of sintered hard metals and other materials.

(4816) Principles and Laws of Reduction to Small Pieces. E. Podszus, *Arch. Metallkunde, 3,* No. 12, 414-22 (1949). Physical processes in pulverizers; energy relations and efficiencies of equipment; physical processes and mathematical treatment of particle reduction; experimental verification of calculations; improvements in pulverizers.

2. MECHANISM OF SINTERING, FRITTING AND BONDING (including diffusion)

(4817) M. Faraday, and J. Stodart, *Experimental Researches in Chemistry and Physics,* 1859, pp. 57-81. Fundamental discussion on diffusion, based on work with mixed metal powders.

(4818) The Crystalline Structure of Metals. J. A. Ewing, and W. Rosenhain, *Phil. Trans. Roy. Soc., A195,* 279-301 (1900). Discussion of artificial grain boundary created by closely contacting two smooth metallic surfaces.

(4819) The Variation of the Melting Point of Eutectic Mixtures. R. Apri, and C. Benedicks, *Metallurgie, 4,* 416-19 (1907). Mixture of Pb and Sn filings used in study of structural changes and fusion.

(4820) Intercrystalline Cohesion in Metals. W. Rosenhain, and D. Ewen, *J. Inst. Metals, 8,* 149-185 (1912). Authors regard the conception of an amorphous intercrystalline cement as established by their tests.

(4821) Intercrystalline Cohesion of Metals. W. Rosenhain, and D. Ewen, *Intern. Z. Metallog., 3,* 276-299 (1913). The so-called "amorphous cement theory" is advanced which postulates that an amorphous substance exists between the crystallites of metals.

(4822) Grain Size Determination and Standardization. Z. Jeffries, *Chem. & Met. Eng., 16,* 503-04 (1917). The mechanism of sintering in tungsten is described. At 2600-2800° C. (4700-5100° F.) the rate of crystal growth is largest.

(4823) Method for Measurement of the Velocity of Crystal Growth in Metals. J. Czochralski, *Z. phys. Chem., 92,* 219-21 (1918). A description is given of a method for obtaining a single crystal wire, *e.g.,* of tungsten.

(4824) Collective Crystallization in Relation to the Atomic Field of Crystals. R. Gross, *Jahrb. Radioakt. Elektronik, 15,* 270-92 (1918). Discussion of the Pintsch process for the production of single crystals of tungsten.

(4825) Grain Growth in Metals. Z. Jeffries, *J. Inst. Metals, 20,* 109–40 (1918). Variation in the grain size of W ingots when sintered at various temperatures is discussed with graphs. Exaggerated or abnormal grain growth is also treated.

(4826) Investigation of the Sintering Process. K. Endell, *Metall u. Erz, 18,* 169-177 (1921). Definition and description of the sintering phenomena.

(4827) Molecular Deposition on Crystals. M. Volmer, and I. Estermann, *Z. Physik, 7,* 13-17 (1921). Planar growth of crystals in a tangential direction is described, such as may be possible in particles of metal powders.

(4828) Effect of Temperature on Ag, Cu, Fe and Pd Powders, Platinum Black and Other Finely Divided Metals. R. Wright and R. C. Smith, *J. Chem. Soc., 119,* No. 2, 1683-8 (1921). Ag, Cu, Fe, Pt, Pd, when deposited electrolytically in a fine state of division, show the phenomenon of sintering at temperatures considerably below their ordinary melting points. This effect may be parallel to the abnormal vapor pressure and solubility of finely divided material. The effect probably has considerable influence on the optimum temperature of a finely divided metal when used as a catalyst.

(4829) On Synthetic Metal Bodies. I. F. Sauerwald, *Z. anorg. u. allgem. Chem., 122,* 277-94 (1922). Grain growth, not preceded by cold-work, in metallic bodies that have been prepared from powdered materials by pressure or by sintering. Grain growth-temperature-pressure relationship.

(4830) Effect of Impurities on Recrystallization and Grain Growth. C. J. Smithells, *Engineering, 113,* 342-6 (1922). Experiments and observations of crystal growth. The vapor pressure hypothesis. The general theory.

(4831) Effect of Impurities on Recrystallization and Grain Growth. C. J. Smithells, *J. Inst. Metals, 27,* 107-34 (1922). Preparation of metals, *e.g.,* W and W compounds. Observations of crystal growth. Effect of impurities. Vapor pressure hypothesis. The general theory.

(4832) Boundary Matter in Metal Crystals. G. Tammann, *Z. anorg. u. allgem. Chem., 121,* 275-80 (1922). In support of the author's special theory of crystallization, a technique to produce intercrystalline, mostly non-metallic, boundary impurities in pure cadmium foil attacked by cold ammonium nitrate is described.

(4833) Metallurgical Applications of Physical Chemistry. C. H. Desch, *J. Chem. Soc., 123,* No. 1, 280-94 (1923). A demonstration is made of surface tension forces as conditioning the shape of gold particles which become spheroidized and lose their sharp angles and edges at 900° C. (1650° F.).

(4834) On Synthetic Metal Bodies. II. F. Sauerwald, *Z. Elektrochem., 29,* 79-85 (1923). Essential factors relating to cold-work on recrystallization according to experiments with metallic bodies prepared from powdered Cu and Fe.

(4835) Sintering: Its Nature and Cause. R. C. Smith, *J. Chem. Soc., 123,* No. 2, 2088-2094 (1923). The sintering of a crystalline substance is due to a change in the size of the crystal. The sintering of an amorphous substance is due to the formation and the growth of crystals.

(4836) Recrystallization of Metals and Salts. G. Tammann and Q. A. Mansuri *Z. anorg. u. allgem. Chem., 126,* 119-28 (1923). Measuring of recrystallization and sintering temperature by the classic stirrer-stop experiments.

(4837) Kinetics of Macro-Crystal Formation in Tungsten through the Union of Small Crystals. H. Alterthum, *Z. phys. Chem., 110,* 1-16 (1924). Thermodynamic consideration of crystal growth at different temperatures.

(4838) Z. Jeffries, and R. S. Archer, *The Science of Metals,* McGraw-Hill, New York (1924). Chap. V – Grain size, growth phenomena in metal powders; sintering.

(4839) Diffusion of Metals in the Solid State. W. Geiss, and J. A. M. Van Liempt, *Z. Metallkunde, 16,* 317-18 (1924). Diffusion in solid metals with natural surfaces in polycrystalline metals and powders.

(4840) On Synthetic Metal Bodies. III. F. Sauerwald, and E. Jaenichen, *Z. Elektrochem., 30,* 175-80 (1924). Strength and density of synthetic metal bodies and the adhesion forces between metallic surfaces, as established during sintering. (See also F. Sauerwald, *Z. Metallkunde, 16,* 41-6 (1924).

(4841) On the Fritting of Metal Oxides and the Adhesion Forces between Oxide-Surfaces. F. Sauerwald, and G. Elsner, *Z. Elektrochem., 31,* 15-18 (1925). Study of strength and density of oxide compacts and compacts of metal powders with oxide skins on particles. Absolute values of strength found less than of compacts of straight metal powders.

(4842) On Synthetic Metal Bodies. IV. F. Sauerwald, and E. Jaenichen, *Z. Elektrochem., 31,* 18-24 (1925). Adhesion forces between metallic surfaces. Cu, Fe, Ni powders used in the investigation. Strength depending on sintering temperature, and in the case of iron effected by $\alpha - \gamma$ transformation.

(4843) Chemical Reactions in Powdered Mixtures of Two Kinds of Crystals. G. Tammann, *Z. anorg. u. allgem. Chem., 149,* 21-98 (1925). Reaction kinetics, velocity dependent on grain size, temperature, etc., mostly non-metallic reactions discussed.

(4844) Equation of State of Solids (Metals), Cohesion and Temperature, and Pressure Coefficients of Cohesion. J. J. Van Laar, *Verslag Akad. Wetenschappen, Amsterdam, 34,* 1303-20 (1925). Mathematical discussion explains temperature and pressure coefficient of cohesion in solid metals.

(4845) Refining of the Surfaces of Metals by Diffusion. G. Grube, and W. v. Fleischbein, *Z. anorg. Chem., 154,* 314-32 (1926). The effect of impurities in the protective atmosphere and the diffusion mechanism in metals is treated.

(4846) Chemical Reactions Taking Place in Mixtures of Solid Substances at High Temperatures. G. Tammann, *Z. angew. Chem., 39,* No. 29, 869-75 (1926). Proof of small amounts of fluid in powdered mixtures is advanced.

(4847) The Temperature of the Beginning of Inner Diffusion in Crystals. G. Tammann, *Z. anorg. u. allg. Chem., 157,* 321-5 (1926). Beginning of diffusion in metal is found at about 1/3 absolute melting point of the metal. The agglomerating during stirring of the fine metal powders, and the crystallization during the heating are caused by the change of the places by the atoms in the lattice.

(4848) Diffusion of Molecules on Surfaces of Solid Bodies. M. Volmer, and G. Adhikari, *Z. phys. Chem., 119,* 46 (1926). Preferential dissolution effects were observed in the sintering of cobalt-tungsten carbide alloys.

(4849) Diffusion of Thorium through Tungsten. P. Clausing, *Physica, 7,* 193-8 (1927). A ThO_2 wire (thoriated W, 1.7% ThO_2) and a Pintsch wire (1-2% ThO_2) were coated with a 20 μ W layer and the mechanism of diffusion investigated.

(4850) Recent Observations on the Occurrences during the Heating of Powder-Forming Substances below Their Melting Points. B. Garre, *Zement, 16,* 404-5 (1927). Granulation of metal powders occurs at 0.3 x abs. melting temperature.

(4851) Sintering of Powdered Substances. J. A. Hedvall, and E. Helin, *Jernkontorets Ann., 82,* 265-342 (1927). High sintering temperature, small and irregular grains give strength. Reduction of Fe_2O_3 with CO gives high shrinkage and strength.

(4852) The Plastic Deformation and Fracture of Metals. W. Rosenhain, *The Engineer, 144,* 422-3 (1927). The amorphous cement theory is advanced in connection with a treatment of the metallic grain boundary.

(4853) Grain Growth in Compressed Metal Powder. C. J. Smithells, W. R. Pitkin, and J. W. Avery, *J. Inst. Metals, 38,* 85-97 (1927). Relation of start of grain growth to particle size and pressure investigated on fine (5 μ) and very fine (<1 μ) tungsten powder; microscopic examination was supported by electrical resistance measurements.

(4854) Capillarity and Surface Tension. G. Bakker, *Handbuch der Experimental-Physik, 6,* 255-70 (1928). The shrinking of thin flakes of gold below the melting point to form spherical particles is attributed to surface tension forces.

(4855) A. F. Joffé, *The Physics of Crystals.* McGraw-Hill, New York, 1928. Values of the cohesive strength of crystals are determined by calculation and experiment.

(4856) Hot-Working of Metals. F. Sauerwald, *Metallwirtschaft, 7,* 1353-58 (1928). Crystallization and resistance against hot-working are discussed. Of interest in studies of the sintering process.

(4857) On Grain Growth and Adhesion Forces in Synthetic Bodies. F. Sauerwald, *Z. Metallkunde, 20,* No. 6, 227-228 (1928). Report of paper of C. J. Smithells, W. R. Pitkin, and J. W. Avery (*cf.* No. 4853) delivered to Institute of Metals.

(4858) Theory of Crystal Growth. I. N. Stranski, *Z. phys. Chem., 136,* 259-278 (1928). In order to determine the growth or dissolution of a crystal, the separation (activation) energy, *i.e.*, the energy necessary to remove a molecule from its position in the surface, must be known.

(4859) Diffusion in Metals in the Solid State. J. A. M. Van Liempt, *Metallwirtschaft, 7,* 558-9 (1928). A review, covering the diffusion of Mo in W, C in W; references.

(4860) Textbook of Metallurgy. F. Sauerwald, *Lehrbuch der Metallkunde, des Eisens und der Nichteisenmetalle.* Springer, Berlin, 1929. On pp. 18-21, grain growth as related to sintering temperature in synthetic (powder) metals is discussed.

(4861) Theory of Recrystallization. G. Tammann, *Z. anorg. u. allgem. Chem., 185,* 1-34 (1929). Author gives a summary of his conceptions on the recrystallization phenomena based on his previously published papers. Reference is made to sintering processes.

(4862) Crystal Formation in Sintered Tungsten Rods. M. Hüniger, *Tech. Wiss. Abhand. Osram-Konzern, 1,* 124-32; *J. Inst. Metals, 47,* 195 (1930). The rods were heated in H by resistance to a current equal to 90% of that required to cause fusion, and the grain size was examined. Factors for crystal growth is found dependent on the history, *i.e.*, method of preparation and treatment of W powder.

(4863) On Recrystallization. G. Tammann, *Z. Metallkunde, 22,* 224-26 (1930). The author "grain boundary substance" theory is elaborated on, and used as an explanation of the noticed influence of temperature on the mechanical properties of metals.

(4864) Studies on the Diffusion of Metals in the Solid State – I. S. Tanaka, and C. Matano, *Mem. Coll. Sci. Kyoto Imp. Univ., A13,* 343-51 (1930). Tests on gold and silver were made. Temperature and time relations were determined.

(4865) Determination of the Coefficient of Diffusion of Metals in the Solid State. S. Tanaka, and C. Matano, *Proc. Phys.-Math. Soc., Japan, 3,* No. 12, 279-84 (1930). Ag and Au diffusion system studied; Frick's law found valid.

(4866) Diffusion of Tin into Iron. C. O. Bannister, and W. D. Jones, *J. Iron Steel Inst., 124,* 71-93 (1931). Diffusion in iron is treated; changes in its rate occur at its alpha-gamma inversion. Special reference is made to the formation of columnar crystals.

(4867) Reactivity of Solids and its Dependence on Factors Causing a Decrease in Density. J. A. Hedvall, *Angew. Chem., 44,* 781-88 (1931). The reactivity of

crystals is based upon the fact that the reaction of the powder mixture is rapid and complete even at low temperatures.

(4868) A Contribution to the Growth and Dissolution of Nonpolar Crystals. I. N. Stranski, *Z. phys. Chem., B11,* 342-49 (1931). The paper contains observations on the growth and the solution of homopolar and metallic crystals.

(4869) Cemented Tungsten Carbide. L. L. Wyman, and F. C. Kelley, *Trans. Am. Inst. Mining Met. Engrs., 93,* 208-230 (1931). Study of the action of cementing material (Co-rich binder) and the mechanism of sintering.

(4870) Studies on the Diffusion of Metals in the Solid State. II. S. Tanaka and C. Matano, *Mem. Coll. Sci. Kyoto Imp. Univ., A14,* 59-66 (1931). Alloys of Au-Cu, Cu-Ni, Au-Ag, Ag-Ni, Ag-Cu are investigated.

(4871) Diffusion of Molybdenum into Tungsten. J. A. M. Van Liempt, *Rec. trav. chim., 51,* 114-132 (1932). The rate of diffusion of molybdenum and tungsten into one another was studied at different temperatures.

(4872) Synthetic Metal Bodies. VII. Crystallization between Surfaces in Structural Equilibrium. F. Sauerwald, and L. Holub, *Z. Elektrochem., 39,* No. 9, 750-53 (1933). Crystal growth in sintered Cu and Fe investigated.

(4873) Recrystallization Effects on Synthetic Metal Bodies. W. Trzebiatowski, *Naturwiss., 21,* No. 10, 205-206 (1933). Study of recrystallization on Cu powder compacts during sintering

(4874) C. H. Desch, *The Chemistry of Solids.* Oxford Univ. Press, London, 1934; Cornell Univ. Press, Ithaca, N. Y., 1934. Sintered crystal boundaries, shrinkage, and surface tension treated on pp. 53-68.

(4875) A Microscopic Examination of Iron-Tin Reaction Products. W. D. Jones, and W. E. Hoare, *J. Iron Steel Inst., 129,* 273-80 (1934). Description of diffusion mechanism in binary alloys resulting in the formation of layers of reaction products equal in number to the phases stable in the binary system at the temperature of diffusion.

(4876) Influence of Diffusing Elements Upon the Alpha-Gamma Inversion of Iron. W. D. Jones, *J. Iron Steel Inst., London, 130,* 429-37 (1934). Diffusion mechanism in alloy steels treated. In order to avoid at once the difficulties in the preparation of alloys of high Fe-content in melts, it was decided to use metal powders.

(4877) Thoriated Tungsten Filaments. I. Langmuir, *J. Franklin Inst., 217,* 543-70 (1934). The diffusion coefficient of thorium in tungsten is investigated for the interior grain boundaries and free surfaces, and it is found that surface diffusion is predominant over internal (volume) diffusion.

(4878) Mechanism of Equilibrium of Small Crystallites. I-III. I. N. Stranski, and R. Kaischew, *Z. phys. Chem., B26,* 100-113, 114-116, 312-316 (1934). The significance of the concept of the mean separation (activation) energy, as introduced by the authors, is shown by examples.

(4879) X-Ray Study of Interdiffusion of Copper and Zinc. E. A. Owen, and L. Pickup, *Proc. Roy. Soc., London, A149,* No. 867, 282-98 (1935). Relations of temperature, particle size, etc., to rate of diffusion are investigated.

(4880) Theory of the Sintering Process. M. Yu. Bal'shin, *Vestnik Metalloprom., 16,* No. 17, 87-120 (1936). Literature survey; discussion of effect of adhesion forces, processes of crystallization, effect of internal stresses, dimensional changes of particles, plasticity of metal; experimental procedure. Results and discussion.

(4881) The Boundaries of Metal Crystals. E. H. Bucknall, *Metal Ind. (London), 49,* No. 13, 311-16; No. 15, 369-73, No. 16, 396-9 (1936). A consideration of intercrysalline penetration by diffusing elements has indicated the importance of active adsorption and points to the probability of the formation of adsorbed layers at grain boundaries and external surfaces.

(4882) The Structure of Some Metallic Deposits on a Copper Single Crystal as Determined by Electron-Diffraction. R. Cochrane, *Proc. Phys. Soc., London, 48,* 723-35 (1936). Tangential growth of nucleated crystallites was found to lead to surface roughness in very thin layers of nickel and cobalt deposits.

(4883) W. Hume-Rothery, *The Structure of Metals and Alloys.* Institute of Metals, London, Monograph and Report Series No. 1, 1936, 120 pp. The electronic background of metallurgy; crystal structure of the elements; atomic radii of the elements; primary metallic solid solutions; intermediate phases in alloy systems; imperfections in crystals and deviations from the ideal lattice. Fundamental theoretical discourse with considerable significance for mechanism of sintering.

(4884) **Diffusion in Solid Metals.** R. F. Mehl, *Trans. Am. Inst. Mining Met. Engrs., 122,* 11-56 (1936). General review of diffusion in solid metals with extensive bibliography. Diffusion rates are affected by size of crystals, *e.g.,* fine-grained powder particles *vs.* single crystals.

(4885) **Computation of Specific Surface-, Edge-, and Corner-Energies of Small Crystals.** I. N. Stranski, *Monatsh. Chem., 69,* 232-242 (1936). The importance of the edge- and corner-energies is investigated.

(4886) **Metallographic Study of the Action of the Cementing Materials for Cemented Tungsten Carbide.** S. Takeda, *Tohoku Imp. Univ. Sci. Repts., 25,* Series 1, Honda Anniv. Vol., 864-81 (1936). WC-Co and WC-Ni systems are investigated. A confirmation of the mechanism of sintering as established by L. L. Wyman and F. C. Kelley, *Trans. Am. Inst. Mining Met. Engrs., 93,* 208-230 (1931) is presented.

(4887) **Crystal Growth across Interfaces.** B. S. Barham, and W. D. Jones, *Metal Ind. (London), 50,* 181-82 (1937. Experiments are described with cast tin and gold ingots having internal shrinkage cavities which are subsequently closed by cold compression, followed by heating; the result was that crystal growth was observed across the interfaces which thus behaved like a grain boundary.

(4888) **Temperature of Recrystallization of Nickel.** E. Fetz, *Metals & Alloys, 8,* No. 12, 339-344 (1937). Carbonyl nickel and electrolytic nickel included in discussion; microstructures of compressed powder compacts.

(4889) **Studies on Interdiffusion of Copper, Tin and Graphite Powders.** T. Ishikawa, *Nippon Kinzoku Gakkai-Si, 1,* No. 6, 226 (1937); *Metal Abstracts, 5,* 477 (1937). The mechanism of sintering of a mixture of 90% Cu, 10% Sn, and 2% graphite was studied by measurement of density, hardness, electrical resistance, expansion, x-ray analysis and microscopic examination.

(4890) W. Jost, *Diffusion und chemische Reaktion in festen Stoffen,* Steinkopff, Dresden-Leipzig, 1937, 231 pp. A treatment of the diffusion processes is presented which includes the discussion of order-disorder phenomena in the crystal lattice and elementary and general processes in reactions in solids.

(4891) **Diffusion on Solid Metals. I–III.** A. I. Krynitsky, *Metals & Alloys, 8,* No. 5, 138-141; No. 6, 173-179; No. 9, 261 (1937). A correlated abstract with 42 references. Influence of temperature; metallography; diffusion of W-Mo treated in addendum.

(4892) **Diffusion of Molybdenum into Iron.** D. A. Prokushkin, *Metallurg, 12,* No. 7, 69-79 (1937). Diffusion experiments with fine metallic Mo powder and Armco Fe in H were carried out. After 3 hrs. at 900° C. (1650° F.) a columnar diffusion zone was observed. At 1100° C. (2010° F.) a sharp boundary line appeared; at 1200° C. (2190° F.) a surface layer was formed.

(4893) **Application of Hahn's Emanation Method to Metal Problems.** W. Seith, and F. Kupferle, *Z. Metallkunde, 29,* 218-22 (1937). Heating of Ag powder; reaction between Sb and Cu powders.

(4894) **Dependence of Diffusion on Grain Size.** Z. Golubenko and S. D. Hertsriken, *Zhur. Tekh. Fiz., 8,* 1219-25 (1938). Cu-Ni powder mixtures investigated; diffusion found to be inverse to grain size.

(4895) **Sintering of Metal Powders and Properties of Metal Compacts.** G. Grube, and H. Schlecht, *Z. Elektrochem., 44,* 367-74, 413-22 (1938). Sintering temperature and grain growth for Mo and Ni-carbonyl powders treated.

(4896) J. A. Hedvall, *Die Reaktionsfähigkeit Fester Stoffe.* Barth, Leipzig (1938). A survey of the structure of solid substances and an investigation

of the reactivity of solid substances is presented. The importance of the condition of solid substances on the sintering and recrystallization processes is shown.

(4897) Sintered Alloys. I. Copper-Nickel-Tungsten Alloys Sintered with a Liquid Phase Present. G. H. S. Price, C. J. Smithells, and S. V. Williams, *J. Inst. Metals, 62,* 239-254 (1938). Mechanism of sintering of tungsten in the presence of the liquid copper-nickel phase is discussed.

(4898) On the Sintering of Several Metals. W. Baukloh, and G. Henke, *Metallwirtschaft, 18,* No. 3, 59-61; *Z. Metallkunde, 31,* 11 (1939). It was found that vacuum is superior to either H_2 or N_2 as atmospheres in the sintering of the readily oxidizing metals.

(4899) Nature of Bonding in Metal Compacts. G. J. Comstock, *Metal Progress, 35,* No. 6, 576-581 (1939). Bonding theories on silver and iron powders developed, and illustrated by microphotographs. Specific effects of pressure and heat, and action of molten cementing material discussed.

(4900) Influence of Sintering Time, Temperature and Pressure on the Tensile Properties of Sintered Iron. W. Eilender, and R. Schwalbe, *Arch. Eisenhüttenwesen, 13,* No. 6, 267-272 (1939). Tensile strength and elongation increase with rising pressure and sintering temperature.

(4901) Sintering of Copper and Tin Powders. H. E. Hall, *Metals and Alloys, 10,* No. 10, 297-8 (1939). Changes in microstructure of compressed Cu-Sn-graphite powder mixtures sintered for various times at 810° C. (1670° F.).

(4902) Manufacture of Non-Ferrous Alloys from Powders. W. D. Jones, *Metal Treatment, 5,* No. 17, 13-16 (1939). The mechanism of sintering in the presence of a liquid metal phase is discussed, and numerous binary combinations of higher and lower melting metal components and their optimum sintering temperatures are given.

(4903) W. Seith, *Diffusion in Metallen,* Springer, Berlin, 1939. A comprehensive treatment of the subject of diffusion in the solid state.

(4904) Growth Phenomena on Cadmium Single Crystals. I. N. Stranski, *Ber. deut. chem. Ges., A72,* 141-148 (1939). Their importance is shown for the determination of the forces acting between the atoms in the crystal lattice.

(4905) The Capillarity of Grain Boundaries of Metals. C. Benedicks, *Kolloid-Z., 91,* 217-32 (1940). An explanation is given of the fact that substances in solid solution are able to increase the temperature of recrystallization and rapid sintering.

(4906) Calculation of the Diffusion Coefficient of Metal Powder Mixtures. S. D. Hertsriken and M. A. Faingold, *Mém. Phys., Kiev, 8,* 127-134; *Met. Abstracts, 8,* 183 (1940). Mathematical treatment. The coefficient of the diffusion of Ni into Cu is $D = 3 \times 10^{-5}$ cm^2. per 24 hrs. at 850° C. (1560° F.).

(4907) Surface Activity of Solid Materials. J. A. Hedvall, *Forschungen u. Fortschritte, 17,* 322 (1941). Explained by an increase of energy derived from the interior and transported by electrons.

(4908) The Calculation of the Diffusion Coefficient in Mixtures of Powdered Substances. S. D. Hertsriken and M. Faingold, *Zhur. Tekh. Fiz., 10,* 574-577; *Chem. Zentr., 111,* II, 2863 (1940). On the assumption of a uniform distribution of the particles in mixtures of powdered substances, a formula was derived theoretically for the calculation of the diffusion coefficient. The diffusion coefficient of powdered Ni in powdered Cu calculated by this formula showed satisfactory agreement with experimental results.

(4909) Powder Metallurgy. C. C. Balke, *Iron Age, 147,* No. 16, 23-27 (1941). Advancement of the "zipper" concept of sintering with the aid of surface tension forces.

(4910) On the Microstructure of Solid Bodies with Elements of Colloidal Size and their Physical and Chemical Properties. R. Fricke, *Kolloid-Z., 96,* No. 2, 211-27 (1941). A discussion of the elements of real solid bodies and their heat content as affected by surface reactions; the surface energies of solid bodies; the energy of active areas; the form of microcrystals; disturbances of the lattice; chemical effects on surface and lattice; secondary structures.

(4911) Fritting of One-Component Powders. I. G. F. Hüttig, *Kolloid-Z., 94,* 137-40 (1941). A theoretical discourse on the principles of bonding and sintering in powder metallurgy and ceramics is given.

(4912) Fritting of One-Component Powders. II. G. F. Hüttig, *Kolloid-Z., 94,* 258-260 (1941). A study of the principles of bonding and sintering is continued.

(4913) The Structure of Fritted Powders. G. F. Hüttig, *Kolloid-Z., 97,* No. 2, 227-230 (1941). Fritting defined as agglomeration of finely divided powders or mixtures of powders which are compressed and heated below initial melting. Industrial importance of fritting outlined.

(4914) Fritting of One Component Powders. A Study of Processes of Powder Metallurgy and Ceramics. G. F. Hüttig, *Kolloid-Z., 97,* No. 3, 281-300 (1941). A comprehensive report on the course of chemical processes involving solids. Systematics and thermodynamics of fritting process.

(4915) The Reactions of Solids. The Course of the Sintering Processes in Copper Powder. G. F. Hüttig, C. Bittner, R. Fehser, H. Hannawald, W. Heinz, W. Hennig, E. Herrmann, O. Hnevkovsky, and J. Pecher, *Z. anorg. u. allgem. Chem., 247,* No. 3, 221-248 (1941). Samples of very pure, finely divided Cu-powder were heated in a stream of hydrogen under constant conditions for 2 hours at temperatures of 100, 200, 300, 400, 500, 700, 800° C. (210, 390, 570, 750, 930, 1290, 1470° F.) After cooling, photomicrographs, x-ray diagrams, density, volume and catalytic action on the decomposition of water were determined. Most important characteristic of the sintering process is the contraction at approximately 400° C.

(4916) Flow of Solid Metals from the Standpoint of the Chemical Rate Theory. W. Kauzmann, *Trans. Am. Inst. Mining Met. Engrs., 143,* 57-83 (1941). A theoretical discourse considers shear forces acting on the crystals and causing microscopic movements resembling chemical reactions.

(4917) Disperse Structure of Solid Systems and Their Thermodynamic Foundation. XI. D. Balarev, and N. Kolarev, *Kolloid-Z., 101,* 277-96 (1942). The process of agglomeration of crystal powders with heat is described. From the temperature-weight curves, it was determined that the temperature can be used as a measure of agglomeration. The temperature of agglomeration depends upon the previous history of the crystal system, and can vary as much as 215° C. (375° F.) for the same powder. The agglomerated structure does not possess a system of any typical crystal structure, but is more or less fused.

(4918) Sintering Characteristics of Various Copper Powders. J. E. Drapeau, Jr., *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 31, pp. 323-331. Procedure, results, data sheets, curves, and a discussion of results are given.

(4919) The Sintering of Powdered Copper-Tin Mixture. J. E. Drapeau, Jr., *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 32, pp. 332-339. Sintering studies relate to materials, equipment, and procedure; results, data sheets, and curves are given with a discussion of results.

(4920) Reactions of Solid Substances: Course of the Sintering Process in Copper Powder as Followed by Its Adsorption Capacity for Dissolved Dyestuffs. J. Hampel, *Z. Elektrochem., 48,* No. 2, 82-84 (1942). Cu powder heated in hydrogen. Alcoholic solution of Congo red and other aqueous solutions studied. Adsorption curves of the dyestuffs were very similar and show maximum adsorption at 200° C. (390° F.). Results discussed in relation to a theory of Hüttig's.

(4921) Fritting of One-Component Powders. A Study of Processes of Powder Metallurgy and Ceramics. G. F. Hüttig, *Kolloid-Z., 98,* No. 1, 6-33; No. 3, 263-286 (1942). Empirical determination on fritting in metal powders and metal oxides, organic substances and glass. Treatment of metal powders. Kinetics of the fritting process. Bibliography.

(4922) Reactions of the Type $A_{(solid)} + B_{(solid)} \longrightarrow AB_{(solid)}$. G. F. Hüttig, *Kolloid-Z., 99,* No. 3, 262-277 (1942). Theoretical discourse relating to mechanisms of diffusion in powders.

(4923) Mechanism for Self-Diffusion in Copper. H. B. Huntington and F. Seitz, *Phys. Revs., 61,* 315-25 (1942). A theory of diffusion is advanced whereby the vacancies in the space lattice migrate.

(4924) Surface Fusion. K. Lichtenecker, *Z. Elektrochem., 48,* 601-04, 669-71 (1942). Description of tests which allow the observation of the melting of metal surfaces of crystallites in a layer of 10^{-3} to 10^{-4} mm. Of significance in sintering.

(4925) Homogenization of Copper-Nickel Powder Alloys. F. N. Rhines, and R. A. Colton, *Trans. Am. Soc. Metals, 30,* No. 1, 166-190 (1942); *Powder Metallurgy.* Am. Soc. Metals, 1942, Chap. 6, pp. 67-86 (1942). Theoretical discourse; experimental procedure; measurements of electrical conductivity as a means of testing progress of diffusion; graphical analysis.

(4926) Observations on Tungsten Single Crystals in the State of Fusion. I. N. Stranski, *Naturwiss., 30,* 662-66 (1942). The changes that take place in the single crystal superstructure during heating to fusion temperature are described.

(4927) Sintering. P. E. Wretblad, and J. Wulff, *Powder Metallurgy.* Am. Soc. Metals, Cleveland, 1942, Chap. 4, pp. 36-59 (1942). Theoretical discourse. Effect of pressure, heat, recrystallization and grain growth. Discussion of occurrences when two surfaces are in contact. Sintering of homogeneous powders; dynamic and static effect of pressing and effect of heat; density and strength of compacts. Heterogeneous systems, influence of gases, surface layers; sintering with a liquid phase.

(4928) Sintering and Melting of Ceramic Raw Materials, Glass, Slag and Coal Ashes as Shown in the Heated Super-Microscope. K. Endell, and M. von Ardenne, *Kolloid-Z., 104,* No. 2/3, 223-231 (1943). Changes in surface structure and texture are shown in several series of photomicrographic films, with order of magnitude of 1-10 microns, and temperatures up to 1450^{0} C. (2640^{0} F.) covered.

(4929) Systematics of Aggregates. G. F. Hüttig, *Kolloid-Z., 104,* No. 2/3, 161-167 (1943). For the recognition of aggregates three determining factors are used. Molecular movability is the determining factor for solids including solid particles during fritting.

(4930) The Fritting of Aluminum Powders in a Vacuum and in Hydrogen. G. F. Hüttig, and T. Freitag, *Z. anorg. u. allgem. Chem., 252,* 95-111 (1943). The adsorption of methanol vapor by Al powders subjected to preheating *in vacuo* and in hydrogen was determined. The adsorption isotherms were interpreted on the basis of Langmuir's theory.

(4931) The Fritting Process in Lead Powders, Observed Dilatometrically. G. Hüttig, and W. Hennig, *Z. anorg. u. allgem. Chem., 251,* No. 3, 260-269 (1943). The linear coefficient of expansion was observed on pressed lead powder specimens *in vacuo,* hydrogen, argon, pure and impure nitrogen and air. Experimental comparisons with solid lead were made.

(4932) Surface Fusion. K. Lichtenecker, *Z. Elektrochem., 49,* 174-78 (1943). Description of tests which allow the observation of the melting of metal surfaces of crystallites in a layer of 10^{-3} to 10^{-4} mm.

(4933) Hedvall's Lattice Distortion Migration. F. Möglich, and R. Rompe, *Physik. Z., 44,* 77-83 (1943). Surface activity of solid substances is a result of energy derived from the interior and transported by electrons.

(4934) The Influence of Homogenization upon the Physical Properties of Copper-Nickel Powder Alloys. F. N. Rhines, and R. A. Meussner, Symposium on Powder Metallurgy, A.S.T.M., Philadelphia, Pa., 1943, pp. 25-30. Experimental procedure, analysis of results, especially the influence of particle size. Discussion.

(4935) Elementary Processes during Fritting and Sintering of Metal Powder. F. Sauerwald, *Kolloid-Z., 104,* No. 2/3, 144-60 (1943). Fritting and sintering of metal powders in relation to their surface structure. Nature of free surfaces; grain boundaries and particle interfaces; diffusion and adhesion phenomena.

(4936) F. Seitz, *Physics of Metals.* McGraw-Hill, New York, 1943. On pp. 183 ff., the lattice vacancies and their movement (migration) in the diffusion process are described.

(4937) Definition of Specific Free Energies of the Edges and Corners of Crystals. I. N. Stranski, *Z. Krist., 105,* 287-95 (1943). The significance of the free energies at the edges and corners of crystals is defined.

(4938) Relationship between Dimensional Changes of Metal Powders and Their Properties. W. Dawihl, and W. Rix, *Z. Metallkunde, 36,* No. 8, 197-200 (1944). Study is made of dimensional changes of metal powder compacts in sintering, by simple dilatometric measurements. Testing set-up and testing procedure is described. An explanation is attempted of differences in shrinkage behavior of different metal powders by the introduction of two new concepts; consideration is given to the influence of porosity upon dimensional changes, and effect of compacting pressure upon start of shrinkage in sintering. Powders studied include cobalt.

(4939) Sintering Powders. Bonding Metal Particles by Heat Alone without Pressure. L. Delisle, *Trans. Electrochem. Soc., 85,* 135-153 (1944); *Steel, 115,* No. 12, 131-132, 154 (1944). Fe, Cu, and Ag powders of different shape and particle size are sintered in hydrogen for 3 hours without previous compaction. Shrinkage and other properties as a function of powder and temperature are discussed.

(4940) Theoretical Basis of the Fritting Process of Powders. G. F. Hüttig, *Metallwirtschaft, 23,* No. 40-43, 367-72 (1944). The changes which a homogeneous powder undergo, if the temperature is gradually increased, are described. A thermodynamic approach to the subject is made on the basis of the theories of Maxwell, Planck and Van Liempt. The results are applied to the changes taking place by heating single crystals, and by heating two or more crystals in contact with each other.

(4941) Degree of Sintering and Strength of Ceramic Materials. E. Ryschkewitsch, *Ber. deut. Keram. Ges., 25,* 95-112 (1944). The mechanism of sintering of oxides is presented on the basis of experimental work.

(4942) The Sintering of Metal Powders – Copper. C. J. Bier, and J. F. O'Keefe, *Trans. Am. Inst. Mining Met. Engrs., 161,* 596-611 (1945). A metallographic study of the mechanism of the sintering process in copper powder was made, illustrating the structural changes that occur as a pressed powder bar is sintered.

(4943) K. Endell, and U. Hofmann, Beiträge zur Theorie des Heftens, Klebens und Bindens. Forsch- und Lehranstalt für das Buchgewerbe, Leipzig, Jan. 1945. *Monatsh. Chem., 78,* No. 3/4, 258-72 (1948). The theoretical background for the process of molecular bonding is treated, and some of the causes for the effects of glueing, binding and adhesion are discussed.

(4944) Viscous Flow under Action of Surface. J. Frenkel, *J. Physics (U. S. S. R.), 9,* No. 5, 385-391 (1945) (in English). It is attempted to interpret the sintering and the formation of crystalline faces on spherical single-crystalline bodies as being due to viscous flow under the action of surface tension. *cf: Met. Powd. Rept., 3,* No. 3, 63 (1945).

(4945) On the Surface Motion of Particles in Crystals. J. Frenkel, *J. Physics (U. S. S. R.), 9,* No. 5, 392-399 (1945) (in English). Processes involving variations of size and shape of crystals are interpreted on the basis of a mechanism involving the motion of surface atoms.

(4946) Capillarity of Metallic Surfaces. E. R. Parker, and R. Smoluchowski, *Trans. Am. Soc. Metals, 35,* 362-373 (1945). It is shown that the balance of changes of the solid-liquid, solid-gas and liquid-gas surface energies depends upon the capillary roughness of the metallic surface. This is of significance in liquid phase sintering.

(4947) Magnetic Method for Testing Diffusion in Metal Powders. P. W. Selwood, and J. Nash, *Trans. Am. Soc. Metals, 35,* 609-615 (1945). The approach to homogeneity is indicated by an irregular lowering of the Curie point.

(4948) Work of Hüttig and Collaborators on Mechanism of Sintering. W. D. Jones, *Metal Treatment, 13,* No. 48, 265-278 (1946). Review of 13 papers so far available from Prague school covering a systematic investigation of changes taking place when metal powders are heated at increasing temperatures.

(4949) Mechanism of Sintering. B. Ya. Pines, *Zhur. Tekh. Fiz., 16,* No. 6, 737-40 (1946); *Sci. Publ. Ukrain. Phys. Tech. Inst. and State Univ.,* Jan. 15, 1946, translated by G. C. Kuczynski; *Met. Powd. Rept., 2,* No. 6, 95 (1948). Sintering is viewed as a process of diffusion of molecular voids through solids.

(4950) G. H. S. Price, *The Sintering of Metal Powders in the Presence of a Liquid Phase with Particular Reference to the Tungsten-Nickel-Copper System.* Dissertation, University of London, 1946. The mechanism of sintering is treated.

(4951) Seminar on Sintering. F. N. Rhines, *Trans. Am. Inst. Mining Met. Engrs., 166,* 474-491 (1946). An outline of the theory of the sintering of pure metal powders, a summary of experimental observations, a composite theory of sintering are presented on the basis of numerous references. Discussion.

(4952) Research in Crystallization Processes in Sintered Soft Iron. H. Wiemer, U. S. Dept. Comm. PB. 14763, 1946, 2 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 17, 937 (1946). The manuscript presents a program according to which the subject research was to be conducted.

(4953) Relationship between Grain Size, Temperature and Sintering. H. Wiemer, U. S. Dept. Comm. PB. 14764, 1946, 2 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 17, 937 (1946). Laboratory research on Kaiser Wilhelm Institut and report of the investigations.

(4954) Sintering Mechanism of Mixtures of Carbides and Binder. U. S. Dept. Comm. PB. 70489, Rept. 131-132, 1947. (F.I.A.T. Microfilm Reel N 56, frames 2198-2213.) Report based on visit of Krupp Widia Werke, Essen. Sintering mechanism elucidated by correlating extent of recrystallization with changes in magnetic saturation.

(4955) Physical Processes Involved in Sintering. D. H. Bangham, *J. Soc. Glass Technol., 31,* 264-66 (1947). Fundamental principles; application to both metals and non-metals.

(4956) A Few Observations on Solid Phase Bonding. G. Durst, *Metal Progress, 51,* No. 1, 97-101 (1947). They include solid phase bonding at low temperatures, the formation of films under heat and pressure. Sticking temperatures of silver, carbonyl iron and copper are determined by the stirring test.

(4957) Reactivity of Solids and Role in Powder Metallurgy. J. A. Hedvall, *Arch. Metallkunde, 1,* No. 7/8, 296-298 (1947). Solid solutions of copper and nickel are best and most rapidly prepared by reducing oxides in stream of hydrogen permits interaction of metals *in statu nascendi.*

(4958) Atomic Theory for Students of Metallurgy. W. Hume-Rothery, *Chem. Eng., 54,* No. 7, 272-275 (1947). Implications to the sintering process are contained in this paper.

(4959) Investigation of Process of Density Increase in the Sintering of Single-Phase Metal Powder Compacts. Part 1. V. A. Ivensen, *Zhur. Tekh. Fiz., 17,* No. 11, 1301-14 (1947). Experimental study aimed at establishing the existence of a constant relative decrease in pore volume (accompanying the increase in density) in the sintering of different single-phase metal powders having a wide range of green densities (porosities). Metal powders studied: copper, nickel, iron, cobalt, tungsten carbide and titanium carbide.

(4960) Investigation of Process of Density Increase in the Sintering of Single-Phase Metal Powder Compacts. Part 2. V. A. Ivensen, *Zhur. Tekh. Fiz., 17,* No. 11, 1315-20 (1947). Derivation of equation for density of sintered compacts, expressed in terms of green density, reguline density, and coefficient (K) of relative decrease in pore volume. Experimental proof, obtained on copper, nickel, and tungsten carbide powders, of correctness of equation. Applicability in industrial practice.

(4961) Formation and Transformation Studies of Iron-Carbon Powder Alloys. J. F. Kahles, *Trans. Am. Soc. Metals, 38,* 618-658 (1947). Results of study of reactions show that very pure steels may be prepared by pack carburizing compressed carbonyl-iron powder, and that austenite transformation characteristics of these powder products do not differ from steel made from the liquid state.

(4962) Influence of "Threshold Effect." F. Mazzoleni, *La Metallurgia Italiana, 39,* No. 2, 86-88 (1947). The threshold effect refers to the critical grain size for metal powders. Theoretical and mathematical analysis is described, including a method for its identification.

(4963) Mutual Solid Solubility of Tungsten Carbide and Titanium Carbide. A. G. Metcalfe, *J. Inst. Metals, 73, Pt. 10,* 591-608 (1947). Results of x-ray investiga-

tion of structure is solid solubility of Ti-carbide in W-carbide.

(4964) F. R. N. Nabarro, *Conference on Strength of Solids*, Univ. of Bristol, 1947. The Physical Society, London, 1948, p. 75. A theory is advanced whereby the forces acting in the surfaces of a body alter the concentrations of lattice defects.

(4965) The Sintering of Metal Powders in the Presence of a Liquid Phase with Particular Reference to the Tungsten–Nickel–Copper System. G. H. S. Price, *Met. Powd. Rept.*, 2, No. 2, 29 (1947). The author's thesis, Univ. of London, 33 pp., is based on the well known paper by G. H. S. Price, S. V. Williams, and C. J. Smithells, *J. Inst. Metals, 62*, 239-264 (1938) dealing with the W-Ni-Cu heavy metal sintering mechanism.

(4966) Seminar on Sintering. F. N. Rhines, *Metal Ind. (London), 70*, No. 14, 226-28 (1947). Condensed version of the seminar on theoretical principles in *Trans. Am. Inst. Mining Met. Engrs., 166*, 474-91 (1946).

(4967) The Physical Metallurgy of Sintered Carbides. E. J. Sandford, and E. M. Trent, *Symposium on Powder Metallurgy*, The Iron and Steel Institute, Special Rept. No. 38, London, 1947, pp. 84-91; *Met. Powd. Rept., 1*, No. 11, 170 (1947). The physical and chemical changes in cemented carbides are discussed in relation to the sintering process, the course of which has been followed by measurement of the contraction and by microscopical examination.

(4968) Theory of Tungsten Carbide-Cobalt System. 1937. Studiengesellschaft Hartmetall. F. D. Rept. No. 3768/47 (1947). This report of 1937 summarizes the sintering theories on the WC-Co system (Hoyt, Wyman and Kelley, and unpublished Osram reports). It enumerates six points requiring further investigation.

(4969) Mechanism of Sintering. Studiengesellschaft Hartmetall. F. D. Rept. No. 3802/47 (1947). This report of 1939 discusses the phases Co_4W, Co_2W and CoW in Sykes' phase diagram, and their formation during sintering.

(4970) Mechanism of Sintering of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3849/47 (1947). A summary of work till 1940 on the mechanism of carbide sintering.

(4971) Crystal Lattice. Studiengesellschaft Hartmetall. F. D. Rept. No. 3909/47 (1947). A brief literature survey was made in 1942 on the possibility of modifying crystal lattices by effecting recrystallization in an electrical or magnetic field.

(4972) Sintering Process. Studiengesellschaft Hartmetall. F. D. Rept. No. 3979/47 (1947). Contribution to the knowledge of the sintering process with hard metals. (Undated draft for an article by Dawihl and Schröter.)

(4973) Solubility Rule in Powder Metallurgy. H. Umstätter, *Arch. Metallkunde, 1*, No. 7/8, 299 (1947). Solubility considered as harmonizing of molecular vibrations, the frequency depending upon surface tension and molecular weight. Effect of increasing temperature is to increase amplitude and wave-length of vibrations.

(4974) Fundamentals of Powder Metallurgy. *Metal Ind. (London), 73*, No. 12, 227, 230 (1948). The mechanism of sintering is described.

(4975) Is Arrhenius's Law Applicable to Sintering Process? K. Adlassnig, and O. Foglar, *Met. Powd. Rept., 3*, No. 1, 9; *Oesterr. Chem. Ztg., 49*, No. 10/11, 181 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 26. Electrolytic copper and carbonyl nickel compacts were sintered for different times and temperatures. Electrical conductivity, density and tensile strength were measured. Arrhenius's law applies, within limits, for complete sintering.

(4976) The Caking of Crystalline Powders and Formation of Crystal Systems. D. Balarew, *Met. Powd. Rept., 2*, No. 12, 182; *Oesterr. Chem. Ztg., 49*, No. 10/11, 176 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 1. According to author's theory of internal adsorption, crystalline substances are formed for thermodynamic reasons as conglomerates with large internal surfaces on which impurities are concentrated. The grain boundary substance in metals is produced by expulsion of internally adsorbed impurities.

(4977) Comment of V.A. Ivensen's Paper Entitled: Investigations of Process of Density Increase in the Sintering of Single-Phase Metal Powder Compacts. M. Yu. Bal'shin, *Zhur. Tekh. Fiz., 18*, No. 10, 1332-35 (1948). Six ways of expressing

the volume characteristics of porous bodies. Identity of Ivensen's formula for constancy of pore volume contraction with author's old formula for the special case of linear correlation between shrinkage and density (porosity).

(4978) Study of Sintering Process with Different Metal Systems by Means of Elastic Measurement. H. J. Bartels, *Met. Powd. Rept., 2,* No. 12, 192; *Oesterr. Chem. Ztg., 49,* No. 10/11, 181 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 29. Elastic modulus measurements on iron powder compacts sintered to different degrees clearly illustrate the course of the sintering process. The same applies to alloy powder compacts, the mixtures of which sinter without or with a liquid phase.

(4979) Self-Diffusion in Iron. C. E. Birchenall, and R. F. Mehl, *J. Applied Phys., 19,* 217-220 (1948). Rates of self-diffusion in alpha- and gamma-iron determined by radioactive tracer techniques. Extrapolation to transformation temperature (910° C., 1670° F.) gave self-diffusion rate for alpha-iron 100 times as great as value for gamma-iron.

(4980) Sintering-Process Study by Electron Micrography. H. Christiensen, and C. J. Calbick, *Phys.Revs., 74,* No. 9, 1219-1220 (1948). Thin flakes of nickel-manganese oxide originally composed of two interdispersed particle size ranges were studied by means of silica replicas of their free surface.

(4981) Studies of the Processes Occurring in Shrinkage of Metal Powders. W. Dawihl, and W. Rix, *Met. Powd. Rept., 3,* No. 1, 9; *Oesterr. Chem. Ztg., 49,* No. 10/11, 181 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 2. When pressings are heated the shrinkage is proportional to the rise in temperature. With ductile metals the beginning of shrinkage and its temperature dependence are governed by compacting pressure, method of manufacture, and previous treatment. Shrinkage is reduction in dimensions due to temperature increase which facilitates packing, and filling of pores through surface tension forces.

(4982) The Formation of Alloys by Diffusion in Powder Metallurgy. P. Duwez, *Met. Powd. Rept., 3,* No. 1, 7; *Oesterr. Chem. Ztg., 49,* No. 10/11, 182 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 69. A study is made of the progressive changes in the structure of Cu-Ni, Cu-Zn, Cu-Sn compacts when heated at a constant rate of 6° F./min. Thermal expansion curves of the compacts during heating were recorded and x-ray diffraction was used to determine the structure at various temperatures. The compacting pressures have no influence on the general shape of the curves.

(4983) Influence of Surface Structure of Powder Particles in Production of Powder Metal Components. S. J. Garvin, *Murex Review, 1,* No. 2, 17-32 (1948). An interesting attempt to explain cohesion in pressings and sintered compacts by comparison with cohesion in cast metals.

(4984) The Occurrence of Columnar Crystals and of Supersaturation during Diffusion in Metals with a Transformation Point. F. Halla, and E. Fitzer, *Met. Powd. Rept., 2,* No. 12, 187; *Oesterr. Chem. Ztg., 49,* No. 10/11, 196 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 39. Columnar crystals are formed when W or Mo is diffused into Fe by immersing the latter in molten sodium tungstate or molybdate above the A_3 point in H. The diffusion begins with the formation of a supersaturated solid γ-solution which diffuses into a mixture of solid α- and γ-solutions as soon as the columnar crystals begin to grow.

(4985) Powder Metallurgy. J. Heuberger, *Festskrift tillägnad J. Arvid Hedvall.* Göteborg, 1948, pp. 241 ff. A theory of sintering is advanced whereby the process is caused mainly by relaxation of lattice disturbances introduced into the particles during the powder manufacture.

(4986) Theoretical Aspects of the Fritting within Powders. G. F. Hüttig, *Arch. Metallkunde, 2,* No. 3, 93-99 (1948). Theory of the fritting phenomena; behavior during temperature increase of a single isolated crystal, and of two or more similar crystals in contact with each otner; sintering of metal powder mixtures.

(4987) The Fundamental Theory of Sintering Processes. G. F. Hüttig, *Met. Powd. Rept., 3,* No. 1, 8; *Oesterr. Chem. Ztg., 49,* No. 10/11, 183 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 22. The author gives a full account of his work to date, divided into three sections; the single crystal; two or more contacting crystals of the same substance; and the sintering of mixed powders. This section distinguishes between powder mixtures that either do or do not form chemical compounds.

(4988) Kinetics of Sintering Compacted Iron Powder. G. F. Hüttig, *Metal Treatment, 15,* 155-58 (1948). An endeavor is made to test the validity of Arrhenius' equation on the results obtained by H. Bernstorff with sintered iron compacts. *Cf.* H. Bernstorff, *Metal Treatment, 15,* No. 54, 85-89 (1948).

(4989) The Mechanism of Sintering of Metal Powders. W. E. Kingston, *Met. Powd. Rept., 3,* No. 1, 6; *Oesterr. Chem. Ztg., 49,* No. 10/11, 183 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 62. With the exception of gas evolution phenomena, the mechanisms of sintering and melting are regarded as synonymous, differing only in the rate of reaction and the nature of the grain boundary material. After interpreting nucleation, recovery, recrystallization and grain growth as progressive stages of diffusion, author considers the nature of metallic surfaces which would readily promote self-diffusion.

(4990) The Nature of Metallic Bonding. M. Koch, *Met. Powd. Rept., 2,* No. 12, 180; *Oesterr. Chem. Ztg., 49,* No. 10/11, 177 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 70. The author postulates that when electricity flows through a metal, the electrones fill lattice vacancies without losing contact with their respective atoms. This theory might be important in connection with intermetallic surfaces.

(4991) Quasi-eutectic Syncrystallization. A. Kofler, *Met. Powd. Rept., 2,* No. 12, 183; *Oesterr. Chem. Ztg., 49,* No. 10/11, 187 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 43. The eutectic point may be displaced through rapid cooling by 10-20%, with binary organic mixtures; the mechanism is discussed with reference to WC-Co compacts, where reprecipitated WC crystallizes out on dissolved WC, permitting crystallization of Co.

(4992) Contact Method for Thermal Analysis. L. Kofler, *Met. Powd. Rept., 2,* No. 12, 182; *Oesterr. Chem. Ztg., 49,* No. 10/11, 187 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 42. A hot-filament microscope with crossed nicol prisms and a film were used to demonstrate the melting and cooling of mixtures of crystalline powders. The author then discussed the sintering of carbides, heavy alloys, porous bronzes, Fe-Ni-Al magnets, where a liquid phase occurs.

(4993) Sintering of Metallic Particles. G. C. Kuczynski, *Bull. Am. Phys. Soc., 23,* No. 7, 25 (1948). A theory of sintering is advanced whereby the process is based on volume and surface diffusion.

(4994) Sintering in Presence of Liquid Phase. F. V. Lenel, *Trans. Am. Inst. Mining Met. Engrs., 175,* 878-905 (1948). In contrast to the mechanism of sintering of metal powders in the solid phase, the sintering in presence of liquid phase cannot be treated as one unified mechanism. Two mechanisms are investigated and reviewed.

(4995) Physical Character of Cohesion between Powder Particles. J. H. McKee, *Phys. Soc. Rep. Conf. of Solids,* 106-115 (1948). The importance of very fine particles, below 2 μ, in reducing porosity and accelerating the sintering is discussed with reference to sintering of sillimanite and glass powder.

(4996) Shrinkage and Expansion in the Sintering of Metals. K. May, *Arch. Metallkunde, 2,* No. 5, 154-63 (1948). Condensed Dissertation, Technische Hochschule, Berlin, 1943. Considering the shrinkage process as the combined effect of atomic mobility and surface cohesion forces, the author makes an interesting attempt to equate these factors.

(4997) Systematics of Alloys. R. Mitsche, *Berg- u. hüttenmänn. Monatsh., montan Hochschule, Leoben, 93,* 163-65 (1948). A modern theoretical presentation is made of the physics of metal alloys as based on diffusion and atomic vibration processes.

(4998) Powder Metallurgy as Research Tool. F. N. Rhines, *Powd. Met. Bull., 3,* No. 2, 28-38 (1948). Mixtures of copper and nickel powders compressed and then heated in reducing atmosphere diffuse together rather slowly. At constant temperature the time is proportional the square of distance between adjacent Cu and Ni particles. Rate also sensitive to composition, reaching highest value at 50:50.

(4999) On the Nature of the Sintering Process. F. Sauerwald, *Oesterr. Chem. Ztg., 49,* No. 10/11, 183 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 6. The simple phenomena during sintering are: adhesion, adsorption, crystallization, equilibrium in the structure, oscillation of atoms, change of place on the surface. Instability of secondary particles and the structure of their surfaces,

shrinkage, effects of cold working, recrystallization. Influence of the amount of pressure on sintering. Influence of gas and impurities on sintering.

(5000) On the Process of Bonding Metals. E. Schwarz-Bergkampf, *Met. Powd. Rept., 2,* No. 12, 180; *Oesterr. Chem. Ztg., 49,* No. 10/11, 177 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 46. Author reports that the passage of weak electric currents through iron powder pressings increased their strength properties considerably, while the temperature increased not more than 2-3° C. (4-5° F.).

(5001) Contribution to a Theory of Sintering. P. Schwarzkopf, *Met. Powd. Rept., 2,* No. 12, 188; *Oesterr. Chem. Ztg., 49,* No. 10/11, 184 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 50. The theory comprises three phases: (*1*) point contacts, conditioned by surface forces; (*2*) lateral growth, assisted by plastic flow; (*3*) disappearance of interconnected porosity, due to surface diffusion rather than lattice diffusion. Plastic flow and surface diffusion occur in all three phases, and are interdependent.

(5002) Diffusion of Carbon in Sintered Steel. W. Seith, *Met. Powd. Rept., 2,* No. 12, 188; *Oesterr. Chem. Ztg., 49,* No. 10/11, 182 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 7. The author interprets the diffusion as place change reactions leading to increased stability. If concentration gradients were not present, diffusion could not be observed. This was confirmed by condensation of radioactive lead on a platinum surface and also by precipitation of radioactive tracers.

(5003) Rate of Sintering of Copper Powder. A. J. Shaler, and J. Wulff, *Phys. Revs., 72,* 79-80 (1947); *73,* 926-27 (1948). *Met. Powd. Rept., 2,* No. 2, 28 (1947). Frenkel's calculations of the coefficient of viscosity and the rate of contraction of single pores were extended to include presence of foreign gases.

(5004) Mechanism of Sintering. A. J. Shaler, and J. Wulff, *Ind. Eng. Chem., Anal. Ed., 40,* No. 5, 838-42 (1948). Shrinkage and expansion occurring in powder compacts during heat treatment are due to the viscous metal flow, whereby the fine pores contract first, larger ones then expand; all pores reaching a stable size.

(5005) The Incipient Reaction between Solid Phases. A. Smekal, *Met. Powd. Rept., 2,* No. 12, 183; *Oesterr. Chem. Ztg., 49,* No. 10/11, 177 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 60. Faint scratches were made with quartz and alumina tools on glass and acrylic resin without producing splinters. The temperature at point of contact increases to above the melting point of one of the substances, or above the eutectic temperature, *e.g.*, 700° C. (1290° F.) for system Na_2O–SiO_2–Al_2O_3.

(5006) Grains, Phases and Interfaces: an Interpretation of Microstructure. C. S. Smith, *Trans. Am. Inst. Mining Met. Engrs., 175,* 15-51 (1948). The subjects of interfacial tension, distribution of liquid phases in alloys, solidification of molten alloys, dependence of grain boundary energy on orientation, and the role played by the contact angle in the wetting of grain surfaces by a molten phase are of particular interest in sintering in the presence of a liquid phase.

(5007) Alloying of Metal Powders by Diffusion. S. Weinbaum, *J. Applied Phys., 19,* 897-900 (1948). The alloy is formed by diffusion during sintering metal or alloy powders. The distribution of metal powders in space is expressed by means of triple series, used to obtain the solution of the diffusion equation. The formula gives the concentration of metal as a function of space, time, temperature, and particle size.

(5008) The Recrystallization during Sintering. May, 1945. H. Wiemer, F. D. Rept. No. 612/48 (1948) (formerly H.E.C. 13769). A two-page report of Kaiser Wilhelm Institut on the recrystallization during sintering.

(5009) Evaluation of Radioactive Isotopes in Metallurgy. C. E. Birchenall, and W. O. Philbrook, *Iron Age, 164,* No. 19, 77-82, 174 (1949). Very informative article with critical introduction, emphasizing various uncertainties that exist. Powder metallurgy is mentioned only in connection with measurement of self-diffusion coefficients, important in sintering.

(5010) Apparatus for Automatic Determination of Instance of Incipient Sintering. P. P. Budnikov, V. M. Barro, and O. P. Mchedlow-Petrosyan, *Doklady Akad. Nauk. S. S. S. R., 67,* No. 1, 113-115 (1949). Development of apparatus for automatic

determination of instance (temperature) of incipient sintering of powdered materials. Detailed description of apparatus. Results of experiments (water-glass powder) with use of proposed apparatus. Importance of new technique for technology of silicates. Applicability of method and apparatus to conductors and its potential usefulness in the field of powder metallurgy.

(5011) Influence of Tensile Forces upon Shrinkage in the Sintering of Metal Powders. W. Dawihl, and W. Rix, *Z. Metallkunde, 40,* No. 3, 115-117 (1949). Relationships in shrinkage of metal powder compacts during sintering. Experimental arrangement and procedure. Metal powder used in experiments: Co powder. Influence of external forces on shrinkage. Difference in shrinkage in direction of tensional force applied and shrinkage normal thereto. Relation between specific weight of sintered compacts and load applied during sintering. Shrinkage of Co powders at 1000/1350° C. (1830-2460° F.) can be reduced by light longitudinal tensile loads of 25 g./mm.^{2} (0.85 psi).

(5012) Study of Mechanism of Sintering of Metallic Particles. J. H. Dedrick, and A. Gerds, *J. Applied Phys., 20,* No. 11, 1042-4 (1949). Results of investigation in which single layers of spherical copper particles have been sintered under varying conditions of time and temperature in dry hydrogen atmosphere; analysis of rate of interface contact between particles has shown metallic sintering to be a diffusion process, in agreement with the theory of G. C. Kuczynski.

(5013) Formation of Alloys by Diffusion in Powder Metallurgy . P. Duwez, *Powd. Met. Bull., 4,* No. 5, 144-56 (1949). The homogenization of Cu-Ni, Cu-Zn, and Cu-Sn compacts was studied by x-ray diffraction and by recording the thermal expansion curves during heating, which is for Cu-Ni compacts similar to that of pure metal; Cu-Zn and Cu-Sn compacts exhibit abnormal expansion.

(5014) Formation of Alloys by Diffusion in Powder Metallurgy — Concluding Part. P. Duwez, *Powd. Met. Bull., 4,* No. 6, 168-74 (1949). Relation between thermal expansion and structure. Preliminary experiments at constant temperature. Study of structure of Cu-Sn compacts.

(5015) Application of Theory of Diffusion to Formation of Alloys in Powder Metallurgy. P. Duwez, and C. B. Jordan, *Trans. Am. Soc. Metals, 41,* 194-212 (1949). The progress of diffusion in compacts of mixed powder of Cu and Ni after heating 32 hrs. at 590-980° C. (1110-1800° F.) was determined by x-ray diffraction.

(5016) Dilatometric Study of Sintering of Metal Powder Compacts. P. Duwez, and H. Martens, *Trans. Am. Inst. Mining Met. Engrs., 185,* 571-77 (1949). Description of systematic investigation of change in length during sintering of compacts made of one or several metal powders; change in length of compacts during sintering was measured with automatic recording dilatometer; compacts made of pure metal; special cases of iron compacts, of prealloyed powders, and compacts containing two metal powders.

(5017) Rates of Reaction in Neighborhood of Magnetic-Transformation Points. Application to Sintering of Iron. H. Forestier and G. Nury, *Bull. soc. chim. France, 16,* Sér. 5, D 193-195 (1949). Results obtained confirmed the previous theory of author, that the rate of the reaction reaches a maximum at the Curie point.

(5018) Activity of Solid Surfaces. R. Fricke, *Z. Elektrochem., 53,* 264-68 (1949). The electron microscope can only give limited explanation of the activity found on solid surfaces, but the "Emanier" method of O. Hahn gives better results. The chemical activation is explained.

(5019) Metallographic Study of the Sintering Process. G. A. Geach, and F. O. Jones, *Research,* 2, 493-94 (1949). Authors describe the results of heating a coil of Cu in H to different temperatures. Polished sections of coil reveal, first the spheroidizing of the pores, and second their contraction.

(5020) Electrical Resistivity Measurements on Iron–Silicon Compacts Prepared by Powder Metallurgy Procedure. F. W. Glaser, *Trans. Am. Inst. Mining Met. Engrs., 185,* 475-80 (1949). Study of progress of diffusion occurring in iron-silicon alloys by electrical resistivity measurements; all samples were prepared by pressing and sintering of compacts; electrical resistance measurements were used to follow progress of alloying under various conditions.

(5021) Diffusion in Iron-Silicon Compacts. F. W. Glaser, *Powd. Met. Bull., 4,* No. 1, 19-22 (1949). Progress of bonding and diffusion during sintering of iron-silicon compacts by means of electrical resistivity measurements is described; results of three series of test specimens shown in tables and explained.

(5022) Reactivity of Solids; Actual Technical Applications and Future Prospects. J. A. Hedvall, *Bull. soc. chim. France, 16,* D238-50 (1949). The recrystallization of sintered Ni-Co alloys and the reactivity during oxidation of Ag-Cd alloys are discussed.

(5023) Densification of Copper Powder Compacts in Hydrogen and in Vacuum. G. B. Jordan, and P. Duwez, *Trans. Am. Inst. Mining Met. Engrs., 185,* 96-99 (1949). Study of change in density of metal powder compacts during sintering; copper was selected as material to be studied first, and its densification followed as function of temperature and time of sintering in hydrogen and in vacuum; experimental procedure; discussion of technique; interpretation of results. Bibliography.

(5024) Self-Diffusion in Sintering of Metallic Particles. G. C. Kuczynski, *Trans. Am. Inst. Mining Met. Engrs., 185,* 169-78 (1949). Radius of interface formed during bonding in simple system composed of spherical particle and large block of same metal was studied as function of time and temperature; it is believed that mechanism involved is fundamental to any sintering operations; mechanism is predominantly that of volume diffusion for large particles and higher temperatures.

(5025) Sintering of Metallic Particles. G. C. Kuczynski, *Phys. Revs., 75,* No. 2, 344 (1949). Spherical copper powder was sintered to flat copper blocks at 400-1000° C. for various times. Analysis of the derived relationship suggests that sintering is caused by volume and surface diffusion.

(5026) Some Problems of Powder Metallurgy Solved by Microscope. G. C. Kuczynski, and I. N. Zavarine, *Mikroskopie, 4,* 193-201 (1949). The sintering of metal and glass spheres to plane surfaces is followed by microscopic measurements of the change in contact area. Volume diffusion operates for coarse particles of metal, and surface diffusion for finer particles.

(5027) A Phenomenological Theory of Sintering. J. K. Mackenzie, and R. Shuttleworth, *Proc. Phys. Soc., B 62,* 833-852 (1949). Authors endeavor to reinterpret most of the recent work by Kuczynski, Frenkel and Shaler with the aid of a new theory based on plastic flow as chief driving force. Densification is believed to occur through surface tension, there being at high temperature a correlation between the rate of shear strain of the metal and the shear stress at constant temperature.

(5028) Surface Migration of Tungsten on Its Own Crystal Lattice. E. W. Müller, *Z. Physik, 126,* 642-65 (1949). Tungsten atoms were deposited from vapor phase on a very fine tungsten point, and the surface migration of the condensed atoms was followed by means of the field-emission electron microscope.

(5029) Seminar on Kinetics of Sintering. A. J. Shaler, *Trans. Am. Inst. Mining Met. Engrs., 185,* 796-813 (1949). Sintering of pure metallic powder; transient and steady state phenomena; recrystallization surface diffusion and evaporation; first phase of sintering; flow in second phase of sintering; rate of sintering in second stage; tables, graphs.

(5030) On the Initiation of Reactions between Solid Phases. A. Smekal. *Powd. Met. Bull., 4,* No. 4, 120-6 (1949). Investigation described illustrates that packing and mixing of loose powders produces, without additional densification by compaction, considerable mechanical stresses at contact points between powder particles; chemical reactions, alloy formation and bonding by fusion are reported.

(5031) The Application of Radiocrystallography to the Study of Sintering. N. Thien-Chi, *Ann. Radioélectricité, 4,* No. 15, 48-53 (1949). Application of radiocrystallography to the study of sintering, with reference to copper-nickel alloys obtained by powder metallurgy; determination of composition of sintered compacts by x-ray diffraction technique; influence of time and particle size on sintering at given temperature.

(5032) Surface Tension of Solid Copper. H. Udin, A. J. Shaler, and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 185,* 186-90 (1949). Description of one group of results of experimental program designed for study of surface tension in solid

metals; information has also been obtained on rate and nature of flow of metal at temperatures approaching melting point and under extremely low stresses.

(5033) Effect of Change of Scale on Sintering Phenomena. C. Herring, *J. Applied Phys., 21,* No. 4, 301-303 (1950). It is pointed out that the effect of scale on the sintering time required to bring a powder aggregate to a certain geometrical configuration depends on the operative mechanism.

(5034) Behavior of Pores during the Sintering of Copper Compacts. F. N. Rhines, C. E. Birchenall, and L. A. Hughes, *Trans. Am. Inst. Mining Met. Engrs., 188,* 378-88 (1950). A mechanism of sintering is advanced on the basis of a study of the behavior (movement, shrinkage and complete sealing) of the pores in the compact.

(5035) Recent Developments in Powder Metallurgy. III. P. Schwarzkopf, *Powd. Met. Bull., 5,* No. 1/2, 4-14 (1950). The theoretical concepts of the process are described with special reference to the various theories of sintering advanced to date, *e.g.*, those by Hedvall, Hüttig, Kingston, Bal'shin, Dawihl, May, Smekal, Shaler, Kuczynski, Herring, Mackenzie and Shuttleworth, and Rhines, Birchenall and Hughes.

(5036) Structure and Behavior of Grain Boundaries. M. R. Achter, and R. Smoluchowski, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 5, pp. 77-91. At low temperatures, the diffusion of silver in copper takes place preferentially along grain boundaries. Experimental results indicated that diffusion seems to have proceeded along certain grain boundaries, by-passing others, and that this grain boundary diffusion was influenced by the orientations of the boundaries.

(5037) Relations Between Diffusion and Viscous Flow in Metals. B. H. Alexander, G. C. Kuczynski, and M. H. Dawson in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 11, pp. 202-213. Measured increases in contact area between heavy copper cylinders and fine copper wires wound around them when heated for increasing lengths of time at 1050-1075° C. (1920-1960° F.) are interpreted as being caused by a mechanism of self-diffusion of lattice vacancies. Creep of gold wires at 1050° C. (1920° F.) is demonstrated as a viscous flow phenomenon, also believed to proceed by migration of lattice vacancies.

(5038) Recrystallization. M. Balicki in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 4, pp. 52-76. Recrystallization is postulated as a rate process in which the conversion from the work hardened to the annealed state takes place through an activated complex, thus explaining the experimentally observed changes in properties during recrystallization.

(5039) Orientation in Recrystallization and Grain Growth. P. A. Beck, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 3, pp. 40-51. The often observed preferred orientation of the grain structure, after recrystallization, grain growth, coarsening, and secondary recrystallization have taken place, is shown to be generally due to the fact that grains having certain preferred orientations have a much faster rate of growth than grains of other orientations.

(5040) Self-Diffusion in Iron. F. S. Buffington, D. Bakalar, and M. Cohen, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 6, pp. 92-108. The self-diffusion constants of alpha and gamma iron were determined by the radioactive tracer method of Steigman, Shockley, and Nix, with special precautions taken to avoid preferential evaporation of the radioactive iron.

(5041) The Sintering of Copper-Gold Alloys. P. Duwez and C. B. Jordan in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 13, pp. 230-237. The metallographic and dilatometric changes during the sintering of binary copper-gold compacts in the absence of a liquid phase are studied, and diffusion processes are followed by x-ray study on compacts corresponding to the compounds AuCu and $AuCu_3$.

(5042) Surface Tension as a Motivation for Sintering. C. Herring in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 8, pp. 143-179. A theoretical development of the rate of material transport in metallic crystals due to surface tension as a motivating force is chiefly based on the concept of differences in chemical potential in a crystal due to differences in temperature, pressure, strain, and number of lattice vacancies.

(5043) Relations between Properties and Structures of Sintered Materials Made Up of a Single Atom Type. G. F. Hüttig, K. Adlassnig, and O. Foglar in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 9, pp. 180-188. Such properties as density, speed of sound, electrical conductivity and modulus of elasticity of powders and sintered matter prepared from powders of single atomic or molecular type are related to the same properties of the compact (solid) substance, and it is shown that the position corresponding to powders is a continuously changeable intermediate one between the solid and the liquid states.

(5044) Theoretical Aspects of Sintering of Carbides. R. Kieffer in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 16, pp. 278-294. A detailed analysis is made of the sintering mechanism of cemented carbides, including some of the recent investigations of the WC-Co system. The solution of cobalt in the tungsten carbide during sintering is believed to be the cause of a "healing" of the imperfections of the WC crystals, with the result that an excellent combination of strength and toughness of the cemented carbides is achieved.

(5045) The Fundamental Problems of Sintering Processes. W. E. Kingston, and G. F. Hüttig, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 1, pp. 1-26. Contains sections on thermodynamics and thermochemistry. The authors present a review of their concepts on the mechanism of sintering of single metals. Surface energy of a metal can, at least in a qualitative way, account for the motivating energy of the sintering process. Also, different kinds of movements of atoms and of atomic aggregates are distinguished which are considered as self-diffusion processes. Formation of recrystallized nuclei during compaction at room temperature and sintering as a rate process are part of the kinetics of the sintering process.

(5046) Sintering with a Liquid Phase. F. V. Lenel, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 14, pp. 238-255. Data are given on the rate of densification of 80-20 iron-copper powder compacts made of different particle size fractions and different grades of iron powder. Measurements were made of the rate of growth of the spherical iron particles during sintering.

(5047) Shrinkage of Synthetic Pores in Copper. A. W. Postlethwaite, and A. J. Shaler in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 10, pp. 189-201. Data on the decrease in volume of an artificial pore, consisting of a hole drilled in a copper wire, during heating at 1000° C. (1830° F.) are designed to establish the fundamental mechanism of densification in powder compacts, which is analogous to a mechanism of viscous flow in which the strain rate is proportional to the stress.

(5048) Mechanism of Crystal Growth. A. G. Smekal, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 2, pp. 27-39. A summary is given of the author's investigations on nucleation, crystal growth and diffusion in rock salt crystals. Observation of these phenomena in ionic crystals is greatly simplified as compared with similar observations on metals, and is believed to facilitate the understanding of similar phenomena in metallic crystals.

(5049) Homogeneous Nucleation. D. Turnbull and J. H. Hollomon in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 7, pp. 109-142. Equations are developed for the rate of homogeneous nucleation on the basis of the absolute rate theory. Values for the surface energy of liquids are derived when applying the equations to such phenomena as the fracture strength of liquids under negative hydrostatic pressure, the temperature to which metals can be undercooled, and the fracture strength of undercooled liquids. Experimental values of surface energy obtained when nucleation occurred homogeneously correspond satisfactorily with values measured by conventional methods.

3. MECHANISM OF COMPACTION
(including friction effects and lubrication)

(5050) R. Hooke, *Micrographia*, London, 1665. Systematic packing of spheres of equal size into a given volume is treated on p. 86.

(5051) Some Experiments Concerning the Cohesion of Lead. J. T. Desaguliers, *Phil. Trans. Roy. Soc., 33*, 345-347 (1724). Determination of the strength of the cohesion between clean surfaces of lead is made.

(5052) O. Goldsmith, *A Survey of Experimental Philosophy*, London, Vols. I and II, 1776. In Vol. I, p. 74, it is stated that, without much outside pressure, strong adhesion exists between clean surfaces of freshly fused lead.

(5053) A Phenomenon of Adhesion. E. Biewend, *Ann. Physik, 57*, No. 133, 164-65 (1842). The strong adhesion between clean surfaces of freshly fused gold without the application of excessive external pressure is described.

(5054) Consolidation of Metal Powders. W. Spring, *Bull. Acad. Roy. Belg., 45*, 746-54 (1878). Alloys of low melting metals were obtained by pressing mixtures of metal powders at temperatures below their melting points.

(5055) Compaction of Metal Powders. W. Spring, *Bull. classe sci. Acad. roy. Belg., 49*, No. 2, 323-379 (1880). Research on welding of solid bodies induced by pressure is reported.

(5056) Union of Bodies by Pressure. W. Spring, *Ann. Chem. Phys., 22*, No. 5, 170-217 (1881). Pressing of Bi, Sn, Zn, Sb powders; Pb, Al and Cu filings, Pt sponge. Also used were powdered sulfites and sulfides and oxides.

(5057) Movements of Particles in Dry Sand. P. Forchheimer, *Z. Oesterr. Ing. u. Architekt-Vereins, 34*, 111-26 (1882). Studies of the effect of applied pressure on masses of fine powders of irregularly shaped particles inside a container.

(5058) Formation of Alloys through Pressure. W. Spring, *Ber., 15*, No. 1, 595-97 (1882). The pressing mechanism is studied on filings of Wood's metal, Rose's alloy and brass.

(5059) A. Heim, *Handbuch der Gletscherkunde*, Stuttgart, 1885. Experiments made with ice, described on p. 220, showed that crystallographically identical surfaces adhere together readily.

(5060) New Method of Forming Alloys. W. Hallock, *Z. phys. Chem., 2*, 378-79 (1888). Research on compacting of powders into solid bodies. Wood's metal made from finely divided metals by pressure.

(5061) The Conductivity of Pressed Powders. F. Streintz, *Ann. Phys., 308*, 1-19 (1900). The conductivity of metal powder pressings (platinum and carbon) is investigated.

(5062) The Conductivity of Pressed Powders. F. Streintz, *Ann. Phys., 314*, 854-85 (1902). The conductivity of powder pressings (mainly metal oxides) is investigated.

(5063) Alloys by Pressure. G. Masing, *Z. anorg. u. allgem. Chem., 62*, 265-309 (1909). Formation of alloys by pressure and reactivity of metals in the solid pulverulent state is investigated.

(5064) The Welding-Together of Solid Bodies by Pressure. T. V. Hagen, *Z. Elektrochem., 25*, 375 (1919). Cylindrical pressings(0.15 g.) of chemical substances pressed at 500 kg./cm.^{2} (7000 psi) show 5 types of behavior (*1*) not pressible, (2) powdery, (*3*) smooth, (*4*) homogeneous, (*5*) plastic. Tests on halides, sulfates, oxides, sulfides, nitrates, carbonates, gypsum, kaolin, salt, potassium chloride, silicon dioxide, aluminum sulfate, potassium sulfate.

(5065) Adherence of Flat Surfaces. H. M. Budgett, *Proc. Roy. Soc., A86*, 25-35 (1911/12). Discussion of adhesion of block gages and forces necessary to overcome it.

(5066) Sliding Friction. C. Jacob, *Ann. Phys., 38,* 126-48 (1912). An increase in the coefficient of friction with temperature is found.

(5067) Thermoelectromotive Force, Peltier Heat, and Thomson Heat under Pressure. P. W. Bridgman, *Proc. Am. Acad. Arts Sci., 53,* 270-386 (1918). The above properties were determined for 20 pure metals and 2 alloys between 0-100° C. (32-212° F.) and a range of pressures up to 12000 kg./cm.^{2} (84 tsi).

(5068) Geology and Ground Waters of San Diego County, California. A. J. Ellis, and C. H. Lee, *U. S. Geol. Survey Water Supply Papers, 446,* 121-3 (1919). Study of the packing of sand, and the effect of particle size on the interparticle porosity.

(5069) Static Friction. W. B. Hardy, and J. K. Hardy, *Phil. Mag., 38,* 32-48 (1919). Demonstration of adherence phenomena on glass beads and plates with special reference to surface and atmospheric conditions, and fluid films.

(5070) Static Friction—Chemical Constitution and the Lubrication of Bismuth. W. B. Hardy, *Phil. Mag., 40,* 201-10 (1920). Attribution of static friction to cohesive or adhesive forces.

(5071) G. Beilby, *Aggregation and Flow of Solids,* MacMillan, London, 1921, 256 pp. Discussion of adherence of metal filings to metal, glass, or zinc globules to steel.

(5072) Boundary Lubrication. W. B. Hardy, and I. Doubleday, *Proc. Roy. Soc., A100,* 550-74 (1921/2). Discussion of static friction in relation to surface conditions. Study of lubrication shows interrelation between friction, seizure, and cohesion.

(5073) The Compressibility of Thirty Metals as a Function of Pressure and Temperature. P. W. Bridgman, *Proc. Am. Acad. Arts Sci., 58,* 166-241 (1923). Determination of compressibility for W, Pt, Mo, Ta, Pd, Ni, Co, Ni, Ag, Cu, U, Au, Al, Ge, Pb, Th, Ce, Ca, Si, Li, Na, K, Mg, Bi, Sn, Sb, Ca, Zn, Te.

(5074) Compressibility of Powders. E. E. Walker, *Trans. Faraday Soc., 19,* 73-82, 614-20 (1923). The compression of powders under static and impact loads, and the creeping of powders under pressure are treated.

(5075) Compressibility of Thirty Metals as a Function of Pressure and Temperature. P. W. Bridgman, *Proc. Am. Acad. Arts Sci., 60,* 305 (1925). Determination of compressibility for W, Pt, Mo, Ta, Pd, Ni, Co, Ni, Ag, Cu, U, Au, Al, Ge, Pb, Th, Ce, Ca, Si, Li, Na, K, Mg, Bi, Sn, Sb, Ca, Zn, Te is continued.

(5076) Phenomena Occurring at Press-Sintering and a Method for Their Investigation. F. Sauerwald, *Stahl u. Eisen, 45,* No. 30, 1274-6 (1925). Fe powder used for the investigation of welding the particles. The influence of material, pressure and temperature. Approach of the particle surfaces.

(5077) L. Archbutt, and R. M. Deeley, *Lubrication and Lubricants.* Griffin, London, 1927, 528 pp. Treatise on the theory and practice of lubrication and on the nature, properties and testing of lubricants.

(5078) A Study of Cohesion and Chemical Attraction. T. W. Richards, *Trans. Faraday Soc., 24,* 111-20 (1927/8). Mathematical treatment of the subject of cohesion.

(5079) Contact of Flat Surfaces. F. H. Rolt, and H. Barrell, *Proc. Roy. Soc., A116,* 401-25 (1927). Discussion of adhesion of block gages on contact of their surfaces.

(5080) Rusting of Steel Surfaces in Contact. G. A. Tomlinson, *Proc. Roy. Soc., A115,* 472-83 (1927). Demonstrates adhesion forces between small globular glass beads and flat surfaces of glass. Also discussion of effects of abrasion and surface contamination.

(5081) Wear and Mechanical Tests of Some Railroad Bearing Bronzes. H. J. French, *Proc. Am. Soc. Testing Matls., 28,* Pt. II, 298-325 (1928). Investigation of conditions governing seizure between metal surfaces.

(5082) Seizing of Metals at High Temperatures. N. L. Mochel, *Proc. Am. Soc. Testing Matls., 28,* Pt. II, 269-75 (1928). Investigation of seizure effects between metallic surfaces.

(5083) Cohesion and Intermolecular Repulsion. R. K. Schofield, *Phil. Mag., 5,* 1171-76 (1928). Discussion of the cohesive forces in highly compressed substances.

(5084) Molecular Cohesion. G. A. Tomlinson, *Phil. Mag., 6,* 695-712 (1928). Experimentation with quartz fibers show deflection in air due to adhesive forces.

(5085) Influence of Surface Conditions on Friction of Metals. R. B. Dow, *Phys. Revs., 33,* 252-57 (1929). Intermetallic friction and adhesion is studied at room temperature and under the influence of various gases.

(5086) A Molecular Theory of Friction. G. A. Tomlinson, *Phil. Mag., 7,* 905-39 (1929). Experimentation on frictional effects between high polished metal surfaces; relation to modulus of elasticity and to plasticity of substance.

(5087) Relation between the Grading and Interstices in Products from Loose Grains. A. H. M. Andreasen, and J. Andersen, *Kolloid-Z., 50,* 217-28 (1930). A study of the packing density of loose powders is made. Theoretical relationships are developed.

(5088) The Nature of Friction. P. E. Shaw, *Phil. Mag., 9,* 628-39 (1930). Studies of the coefficient of friction between metallic surfaces under various conditions.

(5089) Friction of Dry Solids in Vacuo. P. E. Shaw, and E. W. L. Leavey, *Phil. Mag., 10,* 809-22 (1930). An experimental correlation is made between friction, adhesion, plasticity and chemical affinity on clean-cut metal surfaces under vacuum.

(5090) Some Phenomena of Contact of Solids. W. Stone, *Phil. Mag., 9,* 610-20 (1930). Study of adhesion of minute glass beads under different atmospheric conditions.

(5091) Experiments on the Cohesion of Quartz Fibers. G. A. Tomlinson, *Phil. Mag., 10,* 541-4 (1930). Discussion of work by W. Stone on adhesion effects (*cf.* No. 5090).

(5092) The Packing of Particles. A. Westman, and H. R. Hugill, *J. Am. Cer. Soc., 13,* 767-79 (1930). Materials with only one grain size have a porosity of 36.9-39.8%; with two different sizes, the porosity can be diminished to 14.2%.

(5093) Grading Aggregates. F. O. Anderegg, *Ind. Eng. Chem., Ind. Ed., 23,* 1058-64 (1931). Mathematical treatment of packing and grading mixtures of concrete and mortar to obtain maximum density.

(5094) P. W. Bridgman, *The Physics of High Pressure,* Bell & Sons, London, 1931, 390 pp. Discussion of the compressibility of solids, melting under pressure, polymorphic transition under pressure, effect of pressure on thermoelectric properties, and thermal conductivity under pressure.

(5095) Grading Aggregates. C. C. Furnas, *Ind. Eng. Chem., Ind. Ed., 23,* 1052-1058 (1931). Mathematical treatment of packing graded mixtures of concrete to obtain maximum density.

(5096) Considerations and Tests for Materials for High-Temperature, High-Pressure Service. L. W. Spring, *Trans. Bull. Am. Foundrymen's Assoc., 2,* No. 10, 13-55 (1931). An investigation of conditions affecting seizure between metallic surfaces is reported and various materials are compared for high-temperature, high-pressure service.

(5097) The Cohesive Force between Solid Surfaces and the Surface Energy of Solids. R. S. Bradley, *Phil. Mag., 13,* 853-62 (1932). Experimentation and apparatus for determination of cohesive forces between quartz spheres, employing vacuum.

(5098) Physical Properties of Industrial Dusts. R. Meldau, *Z. Ver. deut. Ing., 76,* 1189-1195 (1932). The fine structure of pressed masses is discussed.

(5099) The Fine Structure of Powders in Bulk with Special Reference to Coal. R. Meldau, and E. Stach, Ber. deut. Fech. Wirt. Sach. d. Reichskohlenrats C56, 1933; *J. Inst. Fuel, 7,* 336-54 (1934). Investigation of packing and minimum porosity by systematic arrangement of spheres, flakes, etc.

(5100) Investigation of Friction and Adhesion. B. Derjaguin, *Kolloid-Z., 69,* 155-64 (1934). An adhesion theory is developed for solid bodies which considers the molecular attractive forces.

(5101) Solidification in Pressed Metal Powders. W. Trzebiatowski, *Z. physik. Chem., B24,* 75-86 (1934). Cu and Ag powders were pressed up to 200 tsi. Mechanism of pressing is studied.

(5102) A. S. T. M. and A. S. M. E. Joint Research Committee on Effect of Temperature on Properties of Metals. *Progress Report, Sub-Group N on Wear and Seizure.* (1935). Various investigations are presented.

(5103) Experimental Study of Porosity and Permeability of Plastic Sediments. H. J. Fraser, *J. Geol., 43,* 910-1010 (1935). Determination of the modifications produced in natural deposits; the principles of permeability applied to the problem of distribution of mineral deposits.

(5104) Systematic Packing of Spheres with Particular Relation to Porosity and Permeability. L. C. Graton, and H. J. Fraser, *J. Geol., 43,* 785-909 (1935). Investigation of packings with spheres of different sizes.

(5105) On the Seizure of Surfaces. J. M. Macaulay, *J. Roy. Tech. College, Glasgow, 3,* No. 3, 353-71 (1935). True cohesional forces of very thin freshly cleaved sheets of mica were found to be in the order of 550 psi.

(5106) Progress Rep't., Sub-Group N on Wear and Seizure, ASTM-ASME Joint Research Committee on Effect of Temperature on Properties of Metals, 1935. *Mech. Eng., 58,* 165-8 (1936). Condensed version of original symposium.

(5107) Physical Properties of Surfaces. F. P. Bowden, and K. E. W. Ridler, *Proc. Roy. Soc., A154,* 640-56 (1936). Surface temperature of sliding metals and temperature of lubricated surfaces are treated.

(5108) Physical Properties of Surfaces – Polishing, Surface Flow and Formation of Beilby Layer. F. P. Bowden, and T. P. Hughes, *Proc. Roy. Soc., A160,* 575-587 (1937). The process of polishing is influenced by the relative melting point of the polishing abrasive and the solid. The relative hardness is unimportant.

(5109) Measurement of the Coefficient of Friction. R. Holm, and B. Kirschstein, *Wiss. Veröff. Siemens-Werken, 15,* No. 1, 122-127 (1936). Measurements of the coefficient of friction were made on nickel and platinum, working both with vacuum and with different gaseous atmospheres.

(5110) A Study of Glass Surfaces in Optical Contact. Lord Rayleigh, *Proc. Roy. Soc., A156,* 326-49 (1936). Demonstrates cohesion between optically flat surfaces amounting to 654 psi. Cohesion increases steadily for several hours after contacting.

(5111) Shearing Phenomena at High Pressure, Particularly in Inorganic Compounds. P. W. Bridgman, *Proc. Am. Acad. Arts Sci., 71,* 387-460 (1937). Detailed information is given with respect to technique and investigation of the effect of speed of deformation of compounds. Results are given for measurement of shearing of 250 inorganic compounds.

(5112) A. W. Nash, and A. R. Bowen, *The Principles and Practice of Lubrication.* Chemical Pub. Co. New York, 2nd ed., 1937. A chapter on friction contains interesting discussion of friction of lubricated and unlubricated surfaces.

(5113) Particle Packing and Particle Shape. H. E. White, and S. F. Walton, *J. Am. Ceramic Soc., 20,* 155-166 (1937). Problems of packing of particles are treated. Spherical particles of equal size may be packed in different ways.

(5114) M. D. Aersey, *Theory of Lubrication.* Wiley, New York, 2nd ed., 1938. Series of public lectures on the mechanics of lubrication given at Brown University, also at Yale and M. I. T.

(5115) Theory of the Process of Pressing. M. Yu. Bal'shin, *Vestnik Metalloprom., 18,* No. 2, 124-137 (1938). Investigation of the phenomena in pressing metal powders; basic mathematical relationships; establishing of pressing curves based on the so-called modulus of pressing; relation between pressing curves and original raw material characteristics; relative volume *versus* logarithm of pressure diagrams for various materials; distribution of density in green compacts.

(5116) Powder Metallurgy Alloys and Pseudoalloys. M. Yu. Bal'shin, *Vestnik Metalloprom., 18,* No. 4, 89-96 (1938). The three basic cases in the sintering of multicomponent systems are discussed. Case of mutual insolubility of components studied (system copper-graphite); conclusions drawn and related to system copper-lead. Sintering of systems with limited and unlimited inter-solubility of compo-

nents (system iron-graphite). Completeness of reactions are functions of processing conditions and basic factors; expansion and contraction during sintering discussed.

(5117) The Resistance of Nineteen Metals to 30,000 kg./sq. cm. (210 tsi). P. W. Bridgman, *Proc. Am. Acad. Arts Sci., 72,* 157-205 (1938). The effect of pressure changes on the electrical resistance was determined for Cu, Ag, Au, Fe, Pb, Li, Na, K, Rb, Cs, Ca, Sr, Ba, Hg, Bi and single crystals of Zn, Sn, Sb, and Te.

(5118) The Nature of Metals as Shown by Their Properties under Pressure. P. W. Bridgman, *Trans. Am. Inst. Mining Met. Engrs., 128,* 15-36 (1938). A report is made on experimentation with extremely high pressures and on the phenomena observed, *viz.,* polymorphic transitions under pressure, volume compression, resistivity at high pressures. A theoretical analysis is included.

(5119) The Possibilities of High Pressures in Powder Metallurgy. W. D. Jones, *Metals & Alloys, 9,* No. 5, 125-6 (1938). Discussion of work of P. W. Bridgman, *Proc. Am. Acad. Arts and Sci., 71,* 387-460 (1937).

(5120) The Friction of Clean Metals and Influence of Adsorbed Gases. F. P. Bowden, and T. P. Hughes, *Proc. Roy. Soc. London, A172,* 263-79 (1939). Addition of a trace of O to the metal causes an immediate reduction in the friction. Adsorbed H or N have no effect. The temperature coefficient of the friction between metals was determined over a wide range of temperature.

(5121) The Nature of Sliding and the Analysis of Friction. F. P. Bowden, and L. Leben, *Proc. Roy. Soc., A169,* 371-91 (1939). Sliding is not a continuous process; the motion proceeds in jerks, and large and violant fluctuations occur in the friction.

(5122) Sliding of Metals, Frictional Fluctuations and Vibrations of Moving Parts. F. P. Bowden, L. Leben, and D. Tabor, *Engineer, 168,* No. 4363, 214-17 (1939). Three types of sliding. The real area of contact and the temperature of sliding surfaces. Practical implications.

(5123) The Area of Contact between Stationary and between Moving Surfaces. F. P. Bowden, and D. Tabor, *Proc. Roy. Soc., A169,* 391-412 (1939). Experiments with stationary surfaces show that the area of intimate contact is very small. The real area of contact is not greatly affected by size, shape and degree of roughness.

(5124) Preparation of Metals by Pressing and Sintering. J. D. Fast, *Philips Tech. Rev., 4,* No. 11, 309-16 (1939). It is stated that upon compacting of several powder particles a local temperature increase takes place from a short period at the pressure points, which causes a partial regrouping of the metal atoms at the contact points.

(5125) Nature and Bond of Powder Metal Compacts. C. Hardy, *Metal Progress, 35,* No. 2, 171-74 (1939). Discussion of what holds metal powder compacts together without sintering.

(5126) Great Pressures. J. Basset, *J. phys. radium,* [8] , *1,* No. 4, 121 (1940). Pressures from 50,000 to 100,000 kg./cm.^{2} (350—700 tsi) performed with the technique of Bridgman, at which cylinder and pistons are lined with carbides of great hardness; the cylinder is composed of concentric tubes.

(5127) On the Mechanism of Boundary Lubrication. O. Beeck, J. W. Givens, and A. E. Smith, *Proc. Roy. Soc., A177,* 90-102 (1940). The wear experiments were carried out with a sensitive method which uses metal plated steel balls as its sliding elements.

(5128) On the Mechanism of Boundary Lubrication. O. Beeck, J. W. Givens, and E. C. Williams, *Proc. Roy. Soc., A177,* 103-118 (1940). The structure of thin films of lubricant rubbed on polished mild steel surfaces was investigated by electron diffraction.

(5129) The Friction of Lubricated Metals. F. P. Bowden and L. Leben, *Trans. Roy. Soc., A799,* No. 239, 1-27 (1940). With some lubricants an intermittent clutching and breaking away of the surfaces of sliding metals occurs. However, certain lubricants are able to prevent this and allow continuous sliding.

(5130) New High Pressures Reached with Multiple Apparatus. P. W. Bridgman, *Phys. Revs., 57,* No. 4, 342-43 (1940). The note reports a complete application with a nest of pressure vessels, one within the other, exposed to progressively higher pressures.

(5131) The Influence of Temperature on Lubricating Films. D. Tabor, *Nature, 145,* 308 (1940). The lubricating action of some commercial oils and fatty acids on steel surfaces was studied by using Bowden-Leben apparatus.

(5132) The Physical Aspects of Boundary Lubrications. O. Beeck, *J. Applied Phys., 12,* No. 7, 512-518 (1941). The area of contact between stationary and sliding surfaces. Friction under boundary conditions. Boundary lubrication and wear.

(5133) Explorations toward the Limit of Utilizable Pressures. P. W. Bridgman, *J. Applied Phys., 12,* No. 6, 461-470 (1941). The highest pressures measurable which offer possibility of use as a tool in determining the properties of matter appear to be obtainable by a combination of "short pistons" with high confining pressure. Experiments made on Carboloy bosses and dies.

(5134) Recent Investigations in the Field of Bearing Technology. E. Heidebroek, *Automobiltech. Z., 44,* 349-353 (1941). The effect of bearing metals on lubrication, especially boundary lubrication is shown by number of examples in which all other test conditions were kept constant.

(5135) Studies in Lubrication XI: Friction Phenomena and the Stick–Slip Process. F. Morgan, M. Muskat, and D. W. Reed, *J. Applied Phys., 12,* No. 11, 743-752 (1941). Motion pictures of the slider and table made in order to study possible slipping during the stick phase.

(5136) The Theory of Metallic Friction and the Role of Shearing and Plowing. F. P. Bowden, and D. Tabor, *Bull. Australia Council Sci. Ind. Research,* No. 145, 7-38 (1942). Experimental results given in considerable detail.

(5137) The Friction of Thin Metallic Films. F. P. Bowden, and D. Tabor, *Bull. Australia Council Sci. Ind. Research,* No. 145, 39-59 (1942). Frictional properties of thin films of In, Pb and Cu deposited on other metals were studied.

(5138) The Lubricating Effect of Thin Metallic Films and the Theory of the Action of Bearing Metals. F. P. Bowden, and D. Tabor, *Bull. Australia Council Sci. Ind. Research,* No. 155, 1-24 (1942). Experiments carried out on the friction between sliding surfaces of pure metals, certain alloys and thin films of soft metals deposited on hard metallic substrates.

(5139) Frictional Phenomena X: Lubrication. A. Gemant, *J. Applied Phys., 13,* No. 6, 355-60 (1942). Technical implications of some experimental data discussed. Film lubrication; boundary lubrication.

(5140) Influence of Surface Films of the Dry and Lubricated Sliding of Metals. T. P. Hughes, and G. Whittingham, *Trans. Faraday Soc., 38,* 9-27 (1942). Bowden-Leben apparatus has been used to study the frictional properties of metals covered with various surface films.

(5141) Metal Powders Pressed at Low Temperatures. H. W. Jones, *Light Metals, 5,* No. 51, 95-107 (1942). Physical properties of some Cu, Fe, Al alloys determined after pressing at room temperature and below down to -193° C. (-315° F.), without subsequent sintering.

(5142) Oxidation by Friction Considered as Chemico-Mechanical Process. K. Dies, *Arch. Eisenhüttenw., 16,* 399-407 (1943). The behavior of various parts of metallic materials, when rubbed together under various loads, with or without lubricant was examined by using a special apparatus. The materials included sintered W-Co-C compositions. The results of 17 experiments are tabulated.

(5143) Studies in Lubrication. XII. Friction Behavior during the Slip Portion of the Slip-Stick Process. J. B. Sampson, F. Morgan, D. W. Reed, and M. Muskat, *J. Applied Phys., 14,* No. 12, 689-700 (1943). The jerky form of motion described as "stick-slip" is sometimes observed in the sliding of surfaces and has been studied by an apparatus.

(5144) Geometry of Packing of Spheres. R. Straubel, *Kolloid-Z., 104,* No. 2/3, 167-180 (1943). A theoretical treatment of the subject is given.

(5145) Scientific Principles of Industrial Lubrication. K. L. Wolf, *Oel u. Kohle, 39,* 403-5 (1943). A brief review of the various types of lubrication and the physico-chemical considerations pertaining to them.

(5146) The Packing of Powder Dispersoids in a Limited Space, I and II. K. A. G. Meyer, *Kolloid-Z., 106,* 209-14 (1944). A theoretical and practical discourse on the densest packing of particles by selection of different sizes.

(5147) Lubrication of Metal Surfaces by Fatty Acids. F. P. Bowden, J. N. Gregory, and D. Tabor, *Nature, 156,* No. 3952, 97-101 (1945). The lubricating properties of metal soaps and friction phenomena are reviewed.

(5148) Friction and Lubrication. F. P. Bowden, and D. Tabor, *Ann. Rept. Chem. Soc., 42,* 20-46 (1945). Theory of friction; lubricated surfaces; nature of underlying surface and importance of soap formation; extreme pressure lubrication; chemical decomposition by friction.

(5149) Experiments on the Effect of Pressure on Metal Powder Compacts. J. F. Kuzmick, *Trans. Am. Inst. Mining Met. Engrs., 161,* 612-34 (1945). For relatively short time sintering, molding pressure is a very important factor in the properties of the sintering products.

(5150) The Numerical Symbol of Close Packing of Spheres. G. S. Ldanov, *Doklady Acad. Sci. U. S. S. R., 48,* 39-42 (1945). A close packing of spheres is determined uniquely by the thickness value of the successive layers with parallel and antiparallel packing.

(5151) Packing of Regular and Irregular Particles. H. S. Leftwick, *Nature, 156,* No. 3973, 753 (1945). Discussion of the question that voids in a compact are independent of the size of the container.

(5152) Mechanism of the Pressing of Metal Powders. H. Unckel, *Arch. Eisenhüttenw., 18,* No. 7/8, 161-167 (1945). Pressure distribution in the compact during the pressing operation in making sintered metal compacts was investigated in terms of specific gravity and the Brinell hardness of the resulting materials, determined at various positions on the cross section. Influence of friction at the walls of the mold cylinder and the flow distribution in the powder during pressing were examined and the effects discussed.

(5153) Effect of Certain Known Lubricants on the Pressing of Metal Powder. E. Zampieri, Research Dept. Powder Metallurgy, Stevens Institute of Technology, Hoboken, 1945. A study of the effect of lubricants on the pressing of pure tungsten, carbide, tungsten carbide with 6 and 13% Co and Al powder.

(5154) Sliding Friction under Extreme Pressure. S. J. Dokos, *Trans. Am. Soc. Mech. Engrs., 68,* A148-A156; *J. Applied Mechanics, 13,* 148-56 (1946). In this investigation the variations which occur in the coefficient of friction between clean metal surfaces moving under high loads over a wide range of sliding velocities were studied.

(5155) Pressing Complicated Shapes from Iron Powders. C. G. Goetzel, *Trans. Am. Inst. Mining Met. Engrs., 166,* 506-19 (1946). Pressing mechanism for curved and stepped iron parts is discussed and examples are shown.

(5156) Pressing Powders in the Production of Hard Alloys. G. Samoylov, *Tsventnye Metal., 19,* No. 4, 49-55 (1946); *Chem. Abstr., 41,* No. 8, 1969 (1947). The result of a study of the degree of compressing of a mixture of powders; friction of the compressed mixture in the mold investigated.

(5157) Pressing Operation in the Fabrication of Articles by Powder Metallurgy. R. P. Seelig, and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 166,* 492-505 (1946). Mechanism of compaction and its implications in industrial work. Discussion.

(5158) Relation between Molding Pressure and Porosity of Unfired Refractory Products. A. S. Berezhnoi, *Ogneupory, 12,* No. 3, 124-30 (1947). Experimental study of relationship between true porosity of unfired (semifinished) refractory products and molding pressure is reported. Agreement between porosity calculated according to author's modified formula for true porosity for twenty refractory materials and porosity determined by experiment is shown. Use of author's formula for determining molding pressure in mechanical presses is discussed.

(5159) Friction. F. P. Bowden, *Science News, No. 4,* 139-166 (July 1947); *Met. Powd. Rept., 2,* No. 2, 30 (1947). The subject of friction, treated from a molecular angle, is of interest in the compacting of metal powders.

(5160) The Internal Flow of Granular Masses. R. L. Brown, and P. G. W. Hawksley, *Fuel, 26,* No. 6, 159-73 (1947). The phenomena of packing and flow of particles were studied by using two-dimensional models of ball bearings or sand. Deformation takes place by movement of groups of particles which leads to inhomogeneity.

(5161) Mechanism of Pressing of Iron Powder. F. Eisenkolb, *Stahl u. Eisen, 66/67,* 78-82 (1947). Research is reported on the compaction of powdered iron from different origins.

(5162) Packing of Materials in Bulk. D. R. Hudson, *Machinery (London), 70,* No. 1807, 617-622 (1947). Investigations on packing density of spheres and polyhedral materials are reviewed. Contacts in irregular material; mechanism of density improvement by shaking.

(5163) Plastic Deformation in Metal-Powder Compacts. R. Kamm, M. Steinberg, and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 171,* 439-456 (1947). Investigation of density gradients in cold pressed metal (iron) powder compacts by determined means of deformable lead grid within the powder. After pressing, compact was radiographed, giving the deformed grid pattern, which was analyzed for strain and stress distribution.

(5164) Pressing of Metal Powders. R. P. Seelig, *Australasian Eng.,* 47-49 (April, 1947). The behavior of powders under compression and the physical properties of unsintered powder compacts are reviewed.

(5165) Review of Literature on Pressing of Metal Powders. R. P. Seelig, *Trans. Am. Inst. Mining Met. Engrs., 171,* 506-534 (1947). Seminar on mechanism of pressing at room temperature with discussion is presented.

(5166) Determination of the Pressure in Presses. A. G. Ssamoilow, *Zavodskaya Labs., 13,* 295 (1947). A theory of pressing is developed.

(5167) Compacting of Iron Powders. *Iron Age, 162,* No. 22, 96-98 (1948). A summary of an article on the mechanism of pressing iron powder by F. Eisenkolb in *Stahl u. Eisen, 66/67,* 78-82 (1947).

(5168) Surface Chemistry in Metalworking Operations. *Steel, 123,* No. 23, 130, 133, 144, 146, 148, 154 (1948). Chemical aspects of surface reactions play an important part in wear and lubrication and in powder metallurgy and metal coating fields.

(5169) Surface Energy of Solid Metals. R. Fricke, *Z. Elektrochem., 52,* 72-75 (1948). The free surface energies are investigated for spherical packing, as well as for face centered and body centered cubic packings, and the values are tabulated.

(5170) Method of Measuring Lateral Pressure during Pressing of Metal Powder Compacts. V. N. Goncharova, *Zavodskaya Labs., 13,* 575-78 (1948). Determined according to the deformation of the mold which indicates the forces operating laterally in the mold. Formulas for this computation are given.

(5171) Friction in Powder Metallurgy. H. W. Greenwood, *Metallurgia, 37,* No. 222, 283-84 (1948). Friction at the walls of the die is entirely deleterious and lubricating is necessary. Friction between particles is necessary, as the local heating promotes cohesion, but with high compression ratio it may lead to variations in hardness and density.

(5172) Effect of Compression of Powders. R. Lecuir, *Compt. rend., 226,* 191, 347 (1948). The results show that the compression tends to formation of agglomerates with oriented structure, when occluded air in the mass does not interfere; the orientation is modified by flow of mass.

(5173) The Deformation of Metals in Static and Sliding Contact. A. J. W. Moore, *Proc. Roy. Soc., A195,* 231-44 (1948). An examination of the surface damage produced during the sliding shows that metallic junctions are formed and sheared.

(5174) Development in Pressing Technique of Metal Powders. R. P. Seelig, *Met. Powd. Rept., 3,* No. 1, 4; *Oesterr. Chem. Ztg., 49,* No. 10/11, 191 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 56. Apparatus, theory of

pressing, nature of bond between particles, effect of particle properties, friction, size and shape of pressing.

(5175) Pressing Methods for Manufacture of Complicated Steel Parts. H. Silbereisen, *Arch. Metallkunde, 2,* No. 9, 301-05 (1948). A compression factor for calculating die dimensions is obtained by plotting the bulk volume of the powder against the volumetric compression ratio and reading off the value for apparent density of the given powder.

(5176) Theory of Pressing of Powders. C. Torre, *Berg- u. Hüttenmänn. Monatsh., Montan. Hochschule Leoben, 93,* No. 4/5, 62-67 (1948). Study of plastically deformed powders; generalized flow conditions; diagrams; bibliography.

(5177) Molybdenum Disulphide as Lubricant. *Alloy Metal Rev., 7,* No. 51, 2-8 (1949). High film strength; low coefficient of friction and tenacious adherence of Mo disulfide. Each lamina is composed of a sheet of Mo atoms with a sheet of sulfur atoms on each side.

(5178) Pressure Distribution in Compacting Metal Powders. P. Duwez, and L. Zwell, *Trans. Am. Inst. Mining Met. Engrs., 185,* 137-44 (1949). Pressure at various points on bottom and sides of die 1.50 in. in diameter was measured by means of small piston dynamometers and resistance sensitive strain gages; to correlate results with previous investigations, pressure distribution inside compact was also determined by indirect method based on density measurements.

(5179) Lead-Grid Study of Metal Powder Compaction. R. Kamm, M. A. Steinberg, and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 180,* 694-706 (1949). Lead grid method was described by same authors in T.P. 2133; it was later found that circular hole grids could be more accurately made and, when deformed within powder, more readily measured and analyzed; new results reported.

(5180) Can Plastic Deformation Produce Temporary Melting of Metal? G. Masing, *Z. Metallkunde, 40,* 89-93 (1949). It can be proved thermodynamically that the melting point of metal that is under pressure and separated from its melt by a semi-permeable membrane, should undergo a substantial reduction.

(5181) Determination of Boundary Stresses during Compression of Cylindrical Powder Compacts. M. E. Shank, and J. Wulff, *Trans. Am. Inst. Mining Met. Engrs., 185,* 561-70 (1949). Purpose of paper is to develop experimental method by which non-hydrostatic pressures and shears acting on interior wall of cylindrical die can be measured; such measurements can then be correlated with existing data to aid in explanation of pressing process; theory of method; experimental procedure and results.

(5182) Surface Reactions of Metals. G. Tolley, *Metal Ind. (London), 75,* No. 4, 5, 6, 68-70, 89-91, 112-13 (1949). Physicochemical and physicomechanical reactions studied; measurement of surface roughness; surface area determination; surface corrosion and oxidation; problems of mechanical wear; friction and lubrication.

(5183) Fundamentals of Pressing of Metal Powders. R. P. Seelig, in *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, Chapter 21, pp. 344-371. Various theories on the strength of pressed (green) metal powder compacts are reviewed. Experimental data are presented on the density, strength and electrical resistivity of green copper powder compacts as a function of particle size, lubricant addition, rate of load application, temperature of pressing (*e.g.*, at subnormal levels), number of pressure applications, and pressure dwelling time.

4. EFFECTS OF POWDER CHARACTERISTICS AND PROCESSING VARIABLES ON STRUCTURE AND PROPERTIES

(5184) Conglomerates by Compressing Mixtures of the Powders of Two Metals. G. Tammann, *Z. Elektrochem., 15,* 447-50 (1909). Behavior and electrical conductivity of pressed metal filings on heat treatment.

(5185) The Effect of Drawing on the Crystal Structure of Tungsten Wires. L. P. Sieg, *Proc. Iowa Acad. Sci., 28,* 95-99 (1921). Correlation of modulus of rigidity with the grain size of tungsten. Photomicrographs show the effect of drawing W wire.

(5186) Effect of Temperature, Pressure and Structure on Mechanical Properties of Metal. Z. Jeffries and R. S. Archer, *Chem. & Met. Eng., 27,* 747-51 (1922). A discussion is given of the variation of deformation of a metal with the temperature. Four distinct phases are noted.

(5187) Change of Density of Tungsten by Working. W. Geiss, and J. A. M. Van Liempt, *Ann., 77,* 105-108 (1925). A determination was made of the density of very fine tungsten wires of different diameter; the effect of the degree of working on the property was established.

(5188) The Effect of Working on the Physical Properties of Tungsten. J. W. Avery, and C. J. Smithells, *Proc. Phys. Soc., London, 39,* 85-96 (1926). An explanation is given for the discrepancy obtained by several workers in the determination of the density of very fine tungsten wires. The resistivity was determined and correlated with the change in wire diameter.

(5189) The Physical-Chemical Processes Occurring when Powders are Consolidated without Melting. J. A. Hedvall, *Z. physik. Chem., A123,* 33-85 (1926). Effects of temperature, time of heating, size and shape of particles, pressure; shrinkage and strength of powder agglomerates. Work performed mainly on Fe_2O_3 and Fe_3O_4.

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(5239) Comparative Properties of 0.55 Carbon Steel Bars Formed by Conventional and Powder Metallurgy Methods. A. Squire, *Watertown Arsenal Lab. Rept., 671/18,* July 20, 1944, 8 pp; *U. S. Dept. Comm. PB. 4419/1944* (1944). Data presented in tabular form; steel powder compacts exhibited an unusual combination of strength and ductility in every state of heat treatment.

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effect of sintering atmosphere on physical properties of fine silver compacts; tests on coin and sterling silver compacts, using alloy powders. Ag-Ni-Cu compacts, Ag-CdO compacts; tables, diagrams. Discussion by P. R. Kalischer.

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(5252) The Effect of Sintering Conditions on Mechanical Property-Density Relationship of Iron Powder Compacts. E. M. Rubino, and A. Squire, U. S. Dept. Comm. PB. 4072/1945, 10 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 8, 304 (1945). The report presents in tabular form the data so far obtained in the investigation (See also PB. 4073).

(5253) Effect of Dimensions upon Density and Mechanical Properties of Iron Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept., 671/23,* April 18, 1945, 20 pp.; *U. S. Dept. Comm. PB 49079/1945* (1945). It is shown that dimensions of powder parts of simple geometric shape have an effect upon their over-all density and mechanical properties. Distribution of density within the powder compacts is shown to be dependent upon the condition of pressing. Curves and data are presented.

(5254) The Influence of Processing Conditions upon the Relationship between the Density and Mechanical Properties of Iron Powder Compacts. A. Squire, *Watertown Arsenal Lab. Rept., 671/31,* 1945, 12 pp.; *U. S. Dept. Comm. PB 4073/1945* (1945). It was found that iron powder compacts of any given density have essentially the same tensile strength and ductility, independent of processing methods, provided total sintering, temperature and time are constant.

(5255) Effect of Particle Size on Iron Powder Properties. *Iron Age, 158,* No. 23, 72-76; No. 24, 76-80 (1946). Refers to a wartime research program of investigation of two reduced-type and two electrolytic iron powders.

(5256) Physical Properties of Parts Made from Iron Powder. C. G. Goetzel, *Proc. Second Ann. Spring Meeting Met. Powd. Assoc.,* N. Y., June 13, 1946, 73-79. History of production; effects of processing method on ultimate properties; methods to obtain higher physical properties in ferrous powder products. Comparative data, physical properties of cemented steel and those of carbon-free cemented iron.

(5257) The Use of Ultra-Fine Particles in Powder Metallurgy. H. H. Hausner, *Materials & Methods, 24,* No. 1, 98-102 (1946). The effect of a very small metal powder particle size on uniformity of results in density, break strength, hardness and porosity of powder metal compacts is demonstrated.

(5258) Properties of Sintered Iron-Copper Powders. F. C. Kelley, *Iron Age, 158,* No. 7, 57-60 (1946). Effects of variations in sintering temperature, time and Cu-content, on physical properties of sintered Cu-Fe are discussed.

(5259) Effects of Pressure and Temperature on Iron Powder Compacts. F. C. Kelley, *Metal Progress, 49,* No. 1, 100-102 (1946). Discussion of paper by Heath and Stetkewicz, *Metal Progress, 48,* No. 1, 73-76 (1945).

(5260) The Effect of Particle Size of Iron Powder on the Physical Properties of the Powder and of Iron Compacts. J. F. Kuzmick, U. S. Dept. Comm. PB. 16277/1946; *Bibl. Scient. & Ind. Rept., 1,* No. 21, 1251 (1946). Results of a series of tests which were run to determine the effect of particle size on the physical properties of iron powders and compacts, prepared by standard powder metallurgy techniques. Lots from four different makes of powders were tested.

(5261) Effect of Particle Size on Iron Powder. J. F. Kuzmick, J. D. Shaw, C. L. Clark, T. W. Frank, W. V. Knopp, and A. S. Margolies, *Iron Age, 158,* No. 23, 72-76; No. 24, 76-80 (1946). The effect of particle size of iron powders on the ultimate properties of pressed and sintered compacts is investigated. Tests made on four different iron powders. *Cf.* U. S. Dept. of Commerce PB. 16277, May 31, 1946; *Bibl. Scient. & Ind. Rept., 1,* No. 21, 1251 (1946).

(5262) Some Relationships between Properties of Iron Powders and Properties of Parts Made from Them. F. V. Lenel, *Proc. Second Ann. Spring Meeting of Metal Powder Assoc.,* New York, June 13, 1946, pp. 65-72. The effect of powder

characteristics on density and physical properties is shown and the predominant role played by the green or compact density on the ultimate properties is described.

(5263) Effect of Coining on Precipitation Hardening of Sinteel—P. W. N. Pratt, *Powder Met. Bull., 1,* No. 3, 43-44 (1946). Object of report is to prove beneficial effect of coining operation on precipitation hardening of Sinteel-P (Cu-Ni-Sn). Hardness measurements given.

(5264) Influence of the Processing Conditions upon Density-Mechanical Property Relationship of Iron Powder Compacts. A. Squire, U. S. Dept. Comm. PB. 4073/ 1945, 13 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 8, 304 (1946). The compacts of any given density have the same tensile strength, and same modulus of elasticity, independent of the processing methods.

(5265) Resistivity Measurements on Iron and Steel. R. Steinitz, *Powd. Met. Bull., 1,* No. 1, 6-7 (1946). Research results on tests with pressed, sintered and coined iron compacts. Relation of electrical resistivity *versus* processing variables.

(5266) Densities of Iron Powder Compacts. R. Steinitz, *Powd. Met. Bull, 1,* No. 5, 70-71 (1946). The effect on density of the nature of the powder and the magnitude of the pressure is studied.

(5267) Powder Metal Bronze. H. L. Wain, *Austral. Council Aeronaut. Rept. ACA-25* (June 1946). Description is given of the mechanism of alloying between Cu and Sn particles to form bronze during a heat treatment of Cu-Sn-graphite compacts.

(5268) Investigation of Crystallization of Sintered Soft Iron as a Function of Pressure, Pressing Speed, Temperature, and Powder Quality. H. Wiemer, U. S. Dept. Comm. PB. 6780/1946, 2 pp.; *Bibl. Scient. & Ind. Rept., 1,* No. 16, 860 (1946). The experimental layout, procedural data and results are outlined and discussed.

(5269) Effects of Small Contents of Elements Commonly Present in Steel on the Properties of Sintered Soft Iron with Special Reference to the Effects of the Sintering Atmosphere. H. Wiemer, U. S. Dept. Comm. PB. 14761/1946; *Powd. Met. Bull., 1,* No. 6, 92 (1946). The effect of oxygen, sulfur, phosphorus, and nitrogen on the physical properties of sintered iron are studied.

(5270) Structure of Porous Bronze Bearings. A. Carter and A. G. Metcalfe, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Rept. No. 38, London, 1947, pp. 99-105; *Met. Powd. Rept., 1,* No. 11, 172 (1947). Study of effects of raw materials, and variation of sintering cycle and compacting pressure on density, compressive strength and structure.

(5271) Pressing, Sintering and Properties of Iron-Copper Mixtures. R. Chadwick, E. R. Broadfield and S. F. Pugh, *Symposium on Powder Metallurgy,* The Iron and Steel Institute, Special Rept. No. 38, London, 1947, pp. 151-156; *Met. Powd. Rept., 1,* No. 12, 180 (1947). Four iron powders and two copper powders were used. Effects of variations in the particle size, pressure, sintering temperature were studied.

(5272) Mechanism of Pressing of Iron Powder. F. Eisenkolb, *Stahl u. Eisen, 66/67,* 78-82 (1947). The influence of particle size and of aging and addition of graphite and artificial resin to the iron powder is investigated.

(5273) The Influence of Atom Structure, Atom Volume and Valency on the Hardness of Carbides and Other Hard Alloys. Heraeus-Vacuumschmelze A. G., Hanau. F. D. Rept. No. 1590/47 (1947). A research program to compete with Widia hard metal is derived from theoretical considerations, *e.g.,* TaC with 10% W; WC with Be-Ni; WC or TaC with 10-15% 70/30 Co-Cr: mixtures of WC and TaC with MoC or Cr; TiC with W-Ta; VN with Co or Ni.

(5274) Reduction in Carbon, Sulfur, Oxygen Contents of Iron Powder during Sintering. G. F. Hüttig, *Arch. Metallkunde, 1,* No. 7/8, 359-61 (1947). Experiments made on mixture of iron powder and cast iron powder. C, O, S contents were plotted against sintering temp. (300-1300° C.) both for loose powders and pressed compacts. Addition of $FeCl_2$ results in elimination of O and C at 7-800° C. instead of 1100° C. but does not accelerate sulfur removal.

(5275) Examination and Evaluation of the Metallic Properties of Sintered Products. W. Jung-König, and G. Wassermann, *Metallforschung, 2,* 244-49 (1947). Describes the examination of the hardness, tensile strength, elongation and bending strength of sintered iron bodies and relates these properties to the porosity.

(5276) Pressed and Sintered Iron Powders. W. Rostoker, *Can. Inst. Mining Met., 50,* 497-508 (1947). Study of effect of particle size distribution on physical properties; theories of particle packing; experimental work and results. Relation between packed densities and properties of compacted and sintered powders.

(5277) High Wear Resistance Materials at Elevated Temperatures. P. Schwarzkopf, *Rev. met., 44,* 267-70 (1947). High wear resistance depends on high binding forces among their atoms, and high cohesive strength among individual elements forming them.

(5278) Iron-Graphite Powder Compacts. A. Squire, *Trans. Am. Inst. Mining Met. Engrs., 171,* 473-484 (1947). Paper is based on Watertown Arsenal Laboratory Rept. WAL 671/14 of August 10, 1944 (U. S. Dept. Comm. PB. 4420/1944, 17 pp.). A study is made of effects of raw material processing variations upon the tensile properties of steel formed from mixtures of iron and carbon. The effect of pressing and sintering twice for constant sintering temperature and graphite particle size is investigated.

(5279) Density Relationship of Iron-Powder Compacts. A. Squire, *Trans. Am. Inst. Mining Met. Engrs., 171,* 485-505 (1947). Paper is based on Watertown Arsenal Laboratory Rept. WAL 671/16, of October 31, 1944 (U. S. Dept. Comm. PB. 4417/1944, 28 pp.). Test methods and materials described; relation between density and mechanical properties of compacts and influence of dimensions on density of the compacts investigated; significance of the relationship of density *versus* the ratio of pressing area to wall area of compacts studied.

(5280) Sintered Iron Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3964/47 (1947). Effect of pressing and sintering conditions on properties of sintered iron compacts reported in 1944.

(5281) Sintering of Iron. Studiengesellschaft Hartmetall. F. D. Rept. No. 3967/47 (1947). According to this report of 1944, the tensile strength of sintered iron depends on the size and shape of the iron particles rather than on their hardness.

(5282) Sintered Iron Compacts. Studiengesellschaft Hartmetall. F. D. Rept. No. 3968/47 (1947). The microhardness of sintered iron compacts may be affected by compacting conditions. The effect of the manufacturing method is eliminated by 24 hours' ball-milling. (Report dates back to 1944.)

(5283) Sintering Atmosphere. Studiengesellschaft Hartmetall. F. D. Rept. No. 3969/47 (1947). Effect of sintering atmosphere on the microstructure of TiC-VC materials is discussed in this report of 1944.

(5284) Properties of Metal Powders. Studiengesellschaft Hartmetall. F. D. Rept. No. 3978/47 (1947). Connections between the elongation behavior of the sintered products and the properties of metal powders. (Undated draft for an article by Dawihl and Rix.)

(5285) Thermal Expansion Test for Tungsten Wire. D. E. Tesen, *F. I. A. T. Rept. No. 413,* 7 pp.; *Met. Powd. Rept., 1,* No. 2, 21 (1947). Expansion characteristics of unpressed W powder during sintering at low temperatures are believed to be related to lamp performance of wire produced from the powder.

(5286) Variation of Coercivity with Density of Compacted Ferromagnetic Powders. L. Weil, *Compt. rend., 225,* 229-233 (1947). The coercivities of very fine iron and iron-cobalt powder made by low temperature reduction according to Brit. Pat. 590,392 obey the formula: $H_C = K(d_O - d/d_O)$ where K is a characteristic of the powder, d_O the density of bulk metal, d the apparent density of the compact.

(5287) Thermal Variation of the Coercive Field of Nickel Agglomerates. L. Weil, and S. Marfoure, *J. phys. radium, 7,* No. 12, 358-61 (1947). Obtained by compression of Ni powder at low temperature in H; study of coercive field between -183° C. (-297° F.) and Curie point; it is 3 times smaller than in liquid air at ordinary temperature.

(5288) Determination of the Effect of Particle Size on the Properties of Commercial Iron Powders and Compacts Made from These Powders by Conventional Cold Pressing and Sintering Techniques. Stevens Inst. Technology, Hoboken. 306 pp. (1948). The scope includes 12 standard tests, 5 special tests; statistical analysis of tensile strength of unreduced powders.

(5289) Shrinkage and Properties of Powder Compacts as Function of Their Density (Porosity). M. Yu. Bal'shin, *Zhur. Tekh. Fiz., 18,* No. 9, 1179-84 (1948). Decrease in porosity on sintering in relation to initial porosity is discussed in connection with single-phase and multiphase powder compacts (copper, copper-graphite, copper-tin, iron, iron-copper). Relationship between shrinkage, growth, and mechanical properties, on the one hand, and density, on the other, is shown.

(5290) Time and Temperature Effects in Sintering of Iron Powder. H. Bernstorff, *Metal Treatment, 15,* No. 54, 85-89 (1948). Results of experimental studies made in Degussa laboratories on sintering of DPG Schleuder iron powder up to 10 hrs. at 850-1300° C. (1560-2370° F.); powder preparation, pressing and sintering conditions; mechanical properties; effects of higher temperatures; application of Hüttig's principles.

(5291) Determination of Effect of Particle Size. G. J. Comstock, J. D. Shaw, C. L. Clark, D. C. Kane, W. V. Knopp, A. Lesser, and L. H. Mott, U. S. Dept. Comm. Rept. PB. 95054, 1948. The effect of particle size on the properties of iron powders and compacts by conventional cold pressing and sintering is discussed.

(5292) Non-Uniform Changes in Shape of Metal Powder Compacts during Sintering. H. Franssen, *Arch. Eisenhüttenwesen, 19,* 91-92; *J. Iron Steel Inst., 160,* 442 (1948). The unequal shrinkage of compacts is caused by the non-uniform distribution of the ingredients during pressing, differences in temperature across the section while heating, and influence of specific gravity.

(5293) The Effect of Particle Size on Electrical Properties of Sintered Materials. H. H. Hausner, *Powd. Met. Bull., 3,* No. 1, 4-8 (1948). Electrical resistivity is determined not only by resistivity of components but depends on particle size and shape of components. Copper compacts. Zirconium oxide-talc-graphite.

(5294) Oxide Films formed on Titanium and Zirconium. J. W. Hickman, and E. A. Gulbransen, *Anal. Chem., 20,* 158 (1948). Electron-diffraction technique is used to study the structures of Ti and Zr alloys with Ni, Cu, Co, and of Ti- and Zr-oxides.

(5295) Sintering of Electrolytic Tantalum Powder. R. H. Myers, *Metallurgia, 38,* No. 228, 307-10 (1948). The effect of temperature and time of heating on some properties of pressed electrolytic Ta powders is shown.

(5296) The Influence of Porosity in Ferromagnetic Substances upon the Coercive Force and Approach to Saturation. L. Néel, *Met. Powd. Rept., 2,* No. 12, 189 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 195 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 16. In a concise summary of author's theory of ferromagnetism, formulas are developed for: (*1*) the effect of porosity and inclusions in cast material; (*2*) the approach to saturation as confirmed by tests on sintered iron with porosities of 0.05 to 0.4%; the effect of very fine pores; (*4*) the effect of anisotropic distribution of pores.

(5297) Effect of Inert Gas on Properties of very Fine Wires. K. Torkar, *Met. Powd. Rept., 2,* No. 12, 184; *Oesterr. Chem. Ztg., 49,* No. 10/11, 197 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 25. Characteristic curves were shown for the variation in electrical resistance of Mo wires of 0.1-4 microns diameter, when heated in CO_2, or H. No variation was found in O or N.

(5298) Thermal Variation of the Coercive Field of Powder Agglomerates. L. Weil, S. Marfoure, and P. Bertaut, *J. phys. radium, 9,* No. 8, 203-06 (1948). The effect of temperature on the coercivity was calculated on the basis of experimental data obtained.

(5299) Sintered Products from Iron and Carbon. H. Wiemer, and W. A. Fischer, *Arch. Eisenhüttenwesen, 19,* 125-35 (1948). Effects of particle characteristics, sintering temperature and sintering time experiments and various gas atmospheres including vacuum on structure and mechanical properties; relations of strength; hardness, and density to carbon content, decarburization, heat treatment, etc.

(5300) Relationship of Mechanical Properties of Metal Powder Products to Porosity and Over-all Properties of Porous Compacts. *Doklad. Akad. Nauk U. S. S. R., 67,* 831-34 (1949). Proposes formula based on assumption that the index of mechanical strength is a constant of the material, independent of its porosity.

(5301) Some Effects of Oxygen on Performance of Iron Powder. J. J. Cordiano, *Proc. Fifth Ann. Spring Meeting Metal Powder Assoc.*, Chicago, Apr. 5-6, 1949, 21-35. Iron mill scale was ball milled to a −100 mesh powder and reduced in dry H to produce seven powders varying in oxide content. Summary of results obtained with pressed and sintered compacts.

(5302) On the Relations between Production Process of Iron Powders and Their Crystal Hardness. W. Dawihl, and U. Schmidt, *Z. Metallkunde, 40,* No. 3, 117-119 (1949). Experimental study is made of reasons for differences in microhardness among iron powders (individual ferrite crystals) produced by different processes, such as eddy-milling, atomizing, reduction in increased pressure or ordinary pressure atmospheres. Relationship between microhardness and compacting pressure is established. Results of grinding experiments are given. Explanation of high microhardness of powders obtained by processes not involving fusion, in the form of green or of sintered compacts is made.

(5303) Metallurgical Research in Australia. J. N. Greenwood, *Engineer, 187,* 216-17 (1949). A reference to powder metallurgy concerns work at C. S. I. R. where an investigation is under way to determine the effect of particle size distribution and surface area on the sintering of metal powders.

(5304) Fatigue Strength of Sintered Iron Products. M. Hempel, and H. Wiemer, *Arch. Metallkunde, 3,* No. 1, 11-7 (1949). Influence of the characteristics of powders; effects of porosity and density; relation between fatigue and tensile strengths; tables, charts.

(5305) Relationships between Adsorption Power and Corrosion. G. F. Hüttig, *Berg- u. Hüttenmänn. Monatsh., 94,* 282-4 (1949). Describes experiments on carbonyl iron powder heated in H_2 up to 500° C. (930° F.). Methanol vapor adsorption isotherms gave values in Langmuir's equation which agreed with amounts of Fe dissolved in dilute sulfuric acid.

(5306) Relations between Properties and Structure of Sintered Products. G. F. Hüttig, and K. Torkar, *Kolloid Z., 115,* No. 1-3, 24-35, 35-6 (1949). Question investigated of how Boyle law of substance can be extended to apply to pulverulent conditions; diagram.

(5307) Effect of Oxygen, Nitrogen and Hydrogen on Iodide Refined Titanium. R. I. Jaffee, and I. E. Campbell, *Trans. Am. Inst. Mining Met. Engrs., 185,* 646-54 (1949). Oxygen and nitrogen up to 1 atom % increase the electrical resistivity of Ti, while hydrogen in the same concentration has no effect. Dissolved N changes the microstructure, while H does not affect the microstructure at 0.25 atom % concentration. N has a more potent hardening and strengthening effect than O and decreases the ductility to a greater extent. Unalloyed Ti, the Ti-H alloys, and the 0.25 atom % O alloy could be cold rolled to 95% reduction without edge cracking. Work hardening curves for the various specimens were determined.

(5308) Effects of Impurities in Metal Powders. F. V. Lenel, *Proc. Fifth Ann. Spring Meeting, Metal Powder Assoc.*, Chicago, Apr. 5-6, 1949, 65-73 (1949). Effect of impurities in different metal powders, *e.g.*, Ti, Mo, on the ultimate properties and behavior of the powder metallurgy product are discussed.

(5309) Effects of Sintering of Pressed Silver Powders. E. Raub and W. Plate, *Z. Metallkunde, 40,* No. 5, 171-5 (1949). Effects of sintering temperature on thermal expansion, electrical resistivity and microstructure are discussed; effects of up to 2% of Cd, Zn and Sn additions are shown in photomicrographs and diagrams.

(5310) Magnetic Properties of Iron Compacts in Relation to Sintering Temperature. R. Steinitz, *J. Applied Phys., 20,* No. 7, 712-4 (1949). Results are given of experiments to investigate permeability-density relationship for higher sintering temperatures than previously reported; compared for identical densities, permeability of different iron powders is appreciably higher if sintering is done at 1250-1350° C. (2280-2460° F.) for 24 hrs., instead of 1150° C. (2100° F.) for 1 hr.

(5311) Improvement of Mechanical Properties of Soft Sinter-Iron by Treatment with Oxygen. H. Wiemer and R. Hanebuth, *Arch. Metallkunde, 3,* No. 4, 129-32 (1949). Effects of prior isothermal oxidation upon O_2 content and mechanical properties of sintered compacts are discussed together with effects of particle

properties and pressing on pre-oxidation; post-oxidation of sintered compacts with further sintering is also considered; the structure of oxidized soft iron is shown.

(5312) Electrical Properties as Indicators of the Degree of Sintering. H. H. Hausner, and J. H. Dedrick, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, pp. 320-343. Certain relationships between such basic powder metallurgy variables as powder particle size, compacting pressure, sintering temperature and sintering time, and electrical resistivity and temperature coefficient of resistivity are believed to be of much help in developing a generally acceptable theory of sintering.

5. DETERMINATION AND ANALYSIS OF SPECIFIC OR UNCOMMON PROPERTIES AND CHARACTERISTICS, AND ESPECIALLY, STRUCTURAL PHASES

(5313) On the Electrical Conductivity of Pressed Powders. F. Streintz, *Ann. Physik, 308,* 1-19 (1900); *314,* 854-885 (1902). Tests on platinum black, amorphous carbon, graphite, metal oxides and sulfides are reported.

(5314) A New Molybdenum Carbide. H. Moissan and M. K. Hoffmann, *Ber., 37,* 3324-3327 (1904). The preparation of the compound MoC is described

(5315) Molybdenum-Nickel Alloys. N. Baar, *Z. anorg. Chem., 70,* 352-55 (1911). An investigation of the constitution of the alloy system is reported.

(5316) A Simple Preparation of Molybdenum and Tungsten Carbide. S. Hilpert, and M. Ornstein, *Ber., 46,* 1669-1675 (1913). Investigation of carbides of tungsten. The authors believe that W_3C_4 and W_3C are other tungsten carbide compounds that are stable.

(5317) The Vapor Pressure of Metallic Tungsten. I. Langmuir, *Physik, 14,* 1273-1280 (1913). The rate of evaporation of tungsten *in vacuo* was determined.

(5318) Tungsten and Carbon. O. Ruff, and R. Wunsch, *Z. anorg. allgem. Chem., 85,* 292-328 (1914). A study is made of the system tungsten-carbon. The existence of the hypothetical carbides W_3C_4 and W_3C is discussed, and the solubility of carbon in tungsten is determined.

(5319) The Positive and Negative Temperature Coefficient of Resistance of Non-Electrolytic Conductors. F. Streintz, *Ann. Phys.,* Ser. 4, *44,* 545-555 (1914). The electrical properties,including the temperature coefficient of resistance, of metal powders in the loose and compacted state are treated.

(5320) The Thermal Conductivity of Tungsten. A. G. Worthing, *Phys. Rev.,* Ser. II, *4,* 535-43 (1914). Determination of the thermal conductivity of a tungsten filament at temperatures between 1500 and 2500° K. was calculated from the temperature distribution measured with an optical pyrometer.

(5321) The Melting Point of Tungsten. I. Langmuir, *Phys. Rev.* , Ser. II, *6,* 138-57 (1915). It is proposed that a temperature scale be based on the candle powder of a tungsten filament.

(5322) Compressibilities of Metals. T. W. Richards, and E. P. Bartlett, *J. Am. Chem. Soc., 37,* 470-81 (1915). Compressibility values for tungsten were established.

(5323) The Thomson Effects in Tungsten. A. G. Worthing, *Phys. Rev.,* Ser. II, *5,* 445-51 (1915). Measurements were made of the Thomson e.m.f. for a tungsten filament.

(5324) Arrangement of Atoms in Tungsten. P. Debye, *Physik. Z., 18,* 483-88 (1917). In spite of the fact that x-rays are absorbed by W, it has been found possible to obtain interference figures, from which it is clear that W crystallizes in cubic form, and that the elementary space lattice is a cube.

(5325) Thermal Expansion of Tungsten at Incandescent Temperatures. A. G. Worthing, *Phys. Rev.*, Ser. II, *10,* 638-41 (1917). Measurements were made of the thermal expansion of well-annealed tungsten wire.

(5326) Atomic Heats of Tungsten and of Carbon at Incandescent Temperatures. A. G. Worthing, *Phys. Rev.*, Ser. II, *22,* 199-225 (1918). A linear relationship is obtained between log resistance and log temperature for tungsten, the slope being 1.2 above 1200° K.

(5327) The Reaction between Tungsten and Naphthalene at Low Pressure. M. R. Andrews, and S. Dushman, *J. Franklin Inst., 192,* 545-46 (1921). A study is made of the gradual carburization of a tungsten filament by reaction with hydrocarbons at high temperatures. An investigation of the solubility relationships of carbon in tungsten is also made.

(5328) Linear Expansion of Metals. J. Disch, *Z. Physik, 5,* 173-75 (1921). A determination was made of the linear expansion of tungsten down to −190° C. (−310° F.).

(5329) Crystal Structure of Ti, Zr, Ce, Th and Os. A. W. Hull, *Phys. Rev., 18,* 88-9 (1921). The positions of the lines on the x-ray powder patterns were measured on a slide rule and the planar spacings calculated by the Bragg formula.

(5330) Elongation of Tungsten Wire from One Crystal. H. Schönborn, *Z. Physik, 8,* 377-81 (1921). The elasticity of tungsten wire is discussed.

(5331) Tungsten-Nickel Alloys. R. Vogel, *Z. anorg. allgem. Chem., 116,* 231-42 (1921). A determination was made of the equilibrium diagram of W and Ni from thermal and microscopic examination of a series of alloys made by melting the pure metal powders.

(5332) Cobalt-Tungsten Alloys. K. Kreitz, *Metall u. Erz, 19,* 137-140 (1922). An investigation was carried out on the constitution of tungsten-cobalt alloys.

(5333) The Electro and Magneto-Optical Effects of Liquids Containing Metallic Powders in Suspension. S. Procopiu, *Compt. rend., 174,* 1170-72 (1922). Hg and powders of Al, Cu, Fe, Ni, Zn, Mg were shaken with benzene and the resulting metallic suspensions were examined both in a Kerr apparatus with two vertical electrodes and also between the poles of an electromagnet.

(5334) The Simple Rigidity of Drawn Tungsten Wire at Incandescent Temperatures. W. Schriever, *Phys. Rev.*, Ser. II, *20,* 96-99 (1922). A description is made of a static method used to determine the rigidity at temperatures between 1000 and 2000° K.

(5335) The Variation with Temperature of the Elastic Constants of Tungsten. W. Geiss, *Physica, 3,* 322-7 (1923). A determination was made of the moduli of elasticity and of torsion as a function of the temperature from 290 to 2850° K. for single crystal tungsten wires.

(5336) Measurement of Radiation on Tungsten and Platinum. F. Henning, and W. Heuse, *Z. Physik, 16,* 63-70 (1923). The value for the melting point of tungsten was found to be 3643 ± 50° K.

(5337) Method for the Determination of the Melting Point of Refractory Metal. M. Pirani, and H. Alterthum, *Z. Elektrochem., 29,* 5-7 (1923). A determination is made of the melting point of tungsten at black body conditions. A method for calibrating a pyrometer is discussed.

(5338) Electrical Conductivity of Graphite. E. Ryschkewitsch, *Z. Elektrochem., 29,* 474-8 (1923). Electrical tests on graphite powder compacts show a negative temperature coefficient of resistance upon heating. However, single crystals of graphite have a positive temperature coefficient.

(5339) Single Crystals. C. J. Smithells, *Nature, 111,* 601 (1923). When a tungsten single crystal is broken in tension, a symmetrical wedge-shaped fracture characteristic of a single crystal in the most favorable orientation for slip is obtained.

(5340) Precision Measurements of the Lattice Constants of Pure Metals. W. P. Davey, *Phys. Rev., 23,* 292 (1924). A determination is made of the crystal structure of tungsten and other metals.

(5341) The Simple Rigidity of Drawn Tungsten Wire at Incandescent Temperatures. W. Schriever, *Phys. Rev.,* Ser. II, *23,* 255-258 (1924). The determination of the rigidity of tungsten wire between 1000 and 2000° K. by use of a static method is further described. *Cf. Phys. Rev.,* Ser. II, *20,* 96-99 (1922).

(5342) Diffusion of Carbon through W and W_2C. M. R. Andrews, and S. Dushman, *J. Phys. Chem., 29,* 462-72 (1925). A mathematical theory of diffusion in a wire is given; the solubility of C in W and in W_2C is investigated.

(5343) Precision Measurement of the Lattice Constants of Pure Metals. W. P. Davey, *Phys. Rev., 25,* 753-61 (1925); *26,* 736-38 (1925). A determination is made of the crystal structure of tungsten and other metals.

(5344) Investigation of the Cold Working by Electrical Measurements. W. Geiss, and J. A. M. Van Liempt, *Z. anorg. allgem. Chem., 143,* 259-67 (1925). It was found that Pintsch tungsten single crystals containing 2% thoria have a temperature coefficient of resistance 10% less than that of the pure metal.

(5345) Electrical Measurement on Pure Metals. W. Geiss, and J. A. M. Van Liempt, *Z. Metallkunde, 17,* 194-197 (1925). A determination was made of the resistivity and temperature coefficient of resistance of pure single crystals of tungsten deposited from the hexachloride.

(5346) Tempering of Crystals. F. Koref, *Z. Metallkunde, 17,* 213-20 (1925). The determination of the elongation of tungsten single crystals is discussed.

(5347) Crystal Structure of Titanium and Chromium. R. A. Patterson, *Phys. Rev., 26,* 56-9 (1925). Precision measurement of the crystal structure of the two metals in pure form has been made.

(5348) Reaction Limits of Some Platinum Alloys. Phase study. G. Tammann, *Z. anorg. allgem. Chem., 142,* No. 1, 61-72 (1925). Ni- and Pt-powder are mixed, pressed, heated in H till 1650° C. (3000° F.), rolled heated again to the same temperature; then the scales are melted into test tubes and their variability is observed.

(5349) Deformation of the Lattice of Metals by Mechanical Action. A. E. Van Arkel, *Physica, 5,* 208-12 (1925). From the elasticity functions of the metals it can be calculated that the maximum change in lattice dimensions of stressed metals varies from 0.015 to 0.18% for Pb and W, respectively.

(5350) X-Ray Method of Determining Coefficient of Expansion. K. Becker, *Z. Physik, 40,* No. 1, 37-41 (1926). W-wire, Zr-powder pressed and sintered; Si-carbides are tested.

(5351) The Effect of Tension on Elastic Properties of Wires. E. Edwards, I. Bowen, and S. Alty, *Phil. Mag., 2,* 321-40 (1926). An investigation is made of the effect of tension on the torsional rigidity of tungsten wires.

(5352) Studies on the Deformation of Tungsten Single Crystals. F. S. Goucher, *Phil. Mag., 2,* 289-309 (1926). An x-ray study of the crystals at all stages of their deformation reveals distortions which increase progressively with the degree of deformation.

(5353) The Iron-Tungsten System. W. P. Sykes, *Trans. Am. Inst. Mining Met. Engrs., 73,* 968-1008 (1926). The report includes a tentative equilibrium diagram, photomicrographs of various alloys and measurements of hardness and magnetic properties.

(5354) X-Ray Analysis of WC and MoC. A. Westgren, and G. Phragmen, *Z. anorg. allgem. Chem., 156,* 27-36 (1926). The test bars were produced from metal powders mixed with carbon and sintered. The results are given in tabular form.

(5355) X-Ray Photography of Grain Growth and Improvement of Physical Properties of Tungsten Wires. K. Becker, *Z. Physik, 42,* 226-45 (1927). Debye-Scherer method used for control of wire characteristics.

(5356) Diffusion of Thorium through Tungsten. P. Clausing, *Physica, 7,* 193-8 (1927). It was tried by heating for a long period at high temperature to make Th diffuse into the surrounding W mantle; the result is measured by determination of activation possibilities for thermionic emission.

(5357) Investigation of Rare Metals. P. Clausing, and G. Moubis, *Physica, 7,* 245-50 (1927). Electrical properties, *e.g.*, temperature coefficient of resistance, were investigated for powdered zirconium and titanium.

(5358) The Binary System Cobalt-Tungsten. W. Geiss, and J. A. M. Van Liempt, *Z. Metallkunde, 19,* 113 (1927). The concentration-temperature coefficient curve shows nothing of the existence of one single solid solution. Probably there are two or more different solid solution ranges.

(5359) Electrical Conductivity of Silicon. H. J. Seeman, *Physik. Z., 28,* 765-66 (1927). Temperature coefficient of electrical resistance of powdered and single-crystal silicon was determined.

(5360) On the Magnetostriction of Single Crystals of Iron. N. Akulov, *Z. Physik, 52,* No. 5-6, 389-405 (1928). General formulas for calculation of energy of dilatation of dipole lattices and of electrostriction and magnetostriction of crystals are given. Correlation of curves calculated on basis of these formulas with curves plotted by K. Honda on basis of experimental data.

(5361) The Rate of Evaporation of Tungsten in the Presence of Salt Vapors. H. Alterthum, *Z. tech. Physik, 9,* 285-8 (1928). Measured by the Langmuir method with filaments of 50 and 70 centimeters length, previously ignited in N_2 with some hydrogen to remove impurities.

(5362) The Constitution of Tungsten Carbides. K. Becker, *Z. Elektrochem., 34,* 640-42 (1928). In system W-C three carbides were proved. WC formed below 1900° C. (3450° F.), alpha W_2C between 1900 and 2400° C. (3450 and 4350° F.) and beta W_2C above 2400° C. (4350° F.). Crystal lattices of the compounds are given.

(5363) The System Tungsten-Carbon. K. Becker, *Z. Metallkunde, 20,* No. 12, 437-41 (1928). WC and W_2C [melting point 2700° C. (4700° F.)] have been identified with certainty. W_2C exists in two allotropic modifications; W_3C_2 is believed to exist. Transformation point of W_2C was determined by x-ray investigation (Debye-Scherrer diagrams) and metallography. The conductivity of carburized tungsten wires was also determined.

(5364) Crystal Structure and Linear Coefficient of Thermal Expansion of Tungsten and Tungsten Carbides. K. Becker, *Z. Physik, 51,* 481-9 (1928). X-ray analysis of crystal structure and coefficient of expansion of W, WC, alpha W_2C and beta W_2C.

(5365) Determination of the Atomic Scattering Power for X-Rays from Powders of Gold, Silver and Aluminum for Cu Kα Radiation. J. Brentano, *Phil. Mag.*, [7], *6,* No. 34, 178-91 (1928). The measurements are made with small powder particles of Au, Ag, Al and a method is employed in which the intensities are measured from composite layers.

(5366) Electrical Conductivity of Silicon. H. J. Seeman, *Physik. Z., 29,* 94-95 (1928). Determination of the temperature coefficient of electrical resistance of powdered and single-crystal silicon.

(5367) Equilibrium Diagram of Molybdenum–Carbon System (in English). T. Takei, *Sci. Rept. Tohoku Imp. Univ., 17,* 939-44; *J. Inst. Metals, 40,* 521 (1928). The system has a compound Mo_2C which forms an eutectic with Mo; the crystal structure of the carbide is examined by x-ray method. Mo_2C forms a solid solution in a range of 5.5–6.0% C.

(5368) Widening of Debye–Scherrer Lines of Cold-Worked Tungsten Wire and Ribbon as a Function of Annealing Temperature and Time. A. E. Van Arkel, and W. G. Burgers, *Z. Physik, 48,* 690-702 (1928). Grain recovery of sintered and drawn W-wires investigated.

(5369) A Method for Accuracy of Debye-Scherrer Exposures. A. E. Van Arkel, *Z. Krist., 67,* 235-38 (1928). W and Mo form a complete series of mixed crystals.

(5370) Lattice Distortion of Tungsten Wire. W. G. Burgers, *Z. Physik, 58,* 11-38 (1929). A study is made of the surface layers of tungsten wires from the point of view of lattice distortion.

(5371) Heterogeneous Equilibria of Tungsten and Tungsten Oxides (in English). *Tech. Repts. Tohoku Imp. Univ., 8,* 255, 271 (1929). Equilibria in the system WO_3-W-CO-CO_2 have been determined at different temperatures and in atmospheres with varying contents of CO.

(5372) The Effect of Stress upon X-Ray Reflections from Tungsten Wire. H. L. Cox, and I. Backhurst, *Phil. Mag., 7,* 981-84 (1929). An explanation is given of lattice strain due to cold working.

(5373) Tables of Elastic Properties of Alloys. C. H. Kent, *Univ. of Nevada Bull., 23,* No. 6 (1929). A compilation showing composition and elastic properties of steels, refractory metals (*e.g.*, tungsten, molybdenum, tantalum) and alloys is made.

(5374) X-Ray Notes on the Iron-Molybdenum and Iron-Tungsten Systems. E. P. Chartkoff, and W. P. Sykes, *Trans. Am. Inst. Mining Met. Engrs., 89,* 566-75 (1930). The formation of intermetallic compound phases upon sintering mixture of metal powders is found.

(5375) Characteristics of the Phases of Transition Elements (Ti, V, Cb, Mo, Ta, W) in Binary Systems with B, C and N. G. Hägg, *Z. physik. Chem., B6,* No. 3, 221-32 (1930). The atoms of the metals are arranged in the different phases in the form of cubic-packings of spheres.

(5376) X-Ray Analyses on Molybdenum and Tungsten Nitrides. G. Hägg, *Z. physik. Chem., B7,* No. 5, 339-362 (1930). Structures of Mo and W nitrides obtained (in powdered form) by reaction of metal with ammonia were examined by x-ray. Results.

(5377) Thermal Expansion of Carboloy. P. Hidnert, *Phys. Rev., 35,* No. 1, 120 (1930). The coefficient of expansion of "Carboloy" is larger than that of tungsten.

(5378) Measurement with Liquid Helium. W. Meissner, *Z. Physik, 60,* 181-3; *61,* 191; *65,* 42 (1930). A transition curve for the superconductivity of titanium is given.

(5379) Investigation of Silicon. A. Schulze, *Z. tech. Physik, 11,* 443-50; *Physik. Z., 31,* 1062-64 (1930). Electrical properties of powdered, compacted and single-crystal silicon are determined, with special emphasis on the temperature coefficient of resistance.

(5380) A Study of the Tungsten-Carbon System. W. P. Sykes, *Trans. Am. Soc. Steel Treating, 18,* 968-92 (1930). A tentative equilibrium of the tungsten-carbon system is established with the aid of powders as starting material.

(5381) Metallographic Investigation of the Ternary Alloys of the Iron-Tungsten-Carbon System. S. Takeda, *Tech. Rept., Sendai, 9,* 483-514, 627-664 (1930); *10,* 42-92 (1931). The nature of carbides in tungsten steel was investigated by magnetic analysis and microscopy.

(5382) The Elasticity of Pintsch Crystals of Tungsten. S. J. Wright, *Proc. Roy. Soc., 126,* 613-29 (1930). In tungsten wires of large diameter, it was found that a large percentage of them consisted of two or three crystals, and that the modulus of elasticity was higher than in true single crystal wire.

(5383) X-Ray Investigations on the Hydrides of Ti, Zr, V, and Ta. G. Hägg, *Z. physik. Chem., B11,* No. 5, 433-454 (1931). Crystal structure of systems were carefully studied; samples were prepared from powder.

(5384) Crystal Structure of Hydrides, Borides, Carbides and Nitrides of Transition Elements. G. Hägg, *Z. physik. Chem., B12,* No. 1, 33-56 (1931). The cubic-packing of spheres is found mostly in all kinds of atomic lattice of metals.

(5385) On the Plasticity of Metals. Z. Jeffries, *Mechanical Eng., 53,* No. 4, 262-266 (1931). Plastic deformation of single crystals. Rate of loading an important factor and studies on W filaments.

(5386) Thermal Conductivity of Metal Wires. W. G. Kannuluik, *Proc. Roy. Soc., 131,* 320-35 (1931). Measurements were made of the thermal conductivity of annealed drawn tungsten wire.

(5387) The Electrical Conductivity of Carbon. Z. Nishiyama, *Z. Physik, 71,* 600-15 (1931). Description of experimental work on electrical properties, especially resistivity, of compacted iron powder. Values given after storage at room temperature and after annealing for 20 hours at 90° C. (194° F.). Discussion of particle size and shape effects, and resistivity *vs.* temperature relationship.

(5388) Determination of the Course of Contact Catalytic Reaction by Measurement of the Direct-Current Resistance of Metal Powders during Reaction. L. Reichardt, *Z. Elektrochem., 37,* No. 6, 289-306 (1931). The resistance in d.c. of metal powders during different chemical reactions was measured; difference in sintering of metal powders by reduction from metal oxides was studied.

(5389) Composition Limits of the Alpha-Gamma Loop in the Iron-Tungsten System. W. P. Sykes, *Trans. Am. Inst. Mining Met. Engrs., 95,* 307-12 (1931). The compound Fe_3Mo_2 is found insoluble both in iron and molybdenum.

(5390) Cemented Tungsten Carbide: A Study of Action of Cementing Material. L. L. Wyman, and F. C. Kelley, *Trans. Am. Inst. Mining Met. Engrs., 93,* 208-29 (1931). An investigation of the tungsten-carbon-cobalt ternary system is reported. It is concluded that the η-phase is a double carbide of W and Co, but that it is not of definite composition and exists over a wide range.

(5391) Tungsten-Cobalt System. C. Agte, K. Becker, and F. v. Göler, *Metallwirtschaft, 11,* No. 33, 447-50 (1932). Samples produced by pressing, mixing, sintering in hydrogen. Magnetic, microscopic and x-ray examination.

(5392) Chemical Nature of Oxide Layers Formed on Al, Ti, Zr and Ta by Anodic Polarization. W. G. Burgers, A. Claassen, and J. Zernike, *Z. Physik, 74,* 595-603 (1932). The determination utilized a combination of chemical reaction and x-ray investigation.

(5393) Nickel-Zinc Alloys. W. Heike, J. Schramm, and O. Vaupel, *Metallwirtschaft, 11,* 525-30, 539-42 (1932); *12,* 115-20 (1933). Investigation of the constitution diagram of the system of Ni-Zn by means of sintered alloys.

(5394) The System Iron-Tungsten-Cobalt. W. Köster, and W. Tonn, *Arch. Eisenhüttenwesen, 5,* 431-40 (1932). The constitution of Fe-W-Co alloys was determined.

(5395) The Binary Systems Cobalt-Tungsten and Cobalt-Molybdenum. W. Köster and W. Tonn, *Z. Metallkunde, 24,* 296-301 (1932). An investigation was carried out on the constitution of W-Co and Mo-Co alloys.

(5396) Measurement with Liquid Helium. W. Meissner, *Z. Physik, 75,* 522 (1932). A transition curve for the superconductivity of titanium is given.

(5397) Measurement with Liquid Helium. W. Meissner, H. Franz, and H. Westerhoff, *Ann. Physik, 13,* 555-63 (1932). Low-temperature resistances of Ti, Th, Ba, In and C are given.

(5398) Precision Measurement of Crystal Parameters. E. A. Owen, and J. Iball, *Phil. Mag., 13,* 1020-28 (1932). A determination is made of the crystal structure of tungsten.

(5399) Detection of ZrW_2 Compound by X-Ray Investigation. A. Claassen, and W. G. Burgers, *Z. Krist., 86,* 100-105 (1933). The compound ZrW_2 was found by x-ray investigation, and the structure of the compound is described.

(5400) Thermal and Electrical Conductivities of Metals between −183 and 100° C. (−297 and 212° F.). W. G. Kannuluik, *Proc. Roy. Soc., A141,* 159-68 (1933). Measurements were made of the thermal conductivity and resistivity at low temperatures of Pintsch single crystal tungsten wires.

(5401) The Problem of Permalloy. A. Kussmann, B. Scharnow, and W. Steinhaus, *Heraeus Vakuumschmelze Festschrift,* 310-38 (1933). The distribution of atoms in Ni_3Fe, detected by Dahl, is proved by investigation of the ternary system Ni-Fe-Mn.

(5402) Structure and Lattice Constant of Tungsten. M. C. Neuburger, *Z. Krist., 85,* 232-38 (1933). A discussion is given of the crystal modifications of tungsten.

(5403) The Cobalt-Tungsten System. W. P. Sykes, *Trans. Am. Soc. Steel Treating, 21,* No. 5, 385-423 (1933). Individual metal powders are obtained by reduction; 65-98% W compositions were sintered at 1400-1500° C. (2550-2730° F.) for 25-50 hrs. in a getterized hydrogen atmosphere. A solid solution range was found up to 35% W.

(5404) The Influence of Diffusing Elements upon the Alpha-Gamma Inversion of Iron. W. D. Jones, *J. Iron Steel Inst., 130,* 429-37 (1934). Alloys of iron with tin, antimony and zinc were made by mixing finely divided (300 mesh) iron powder with coarse filings of the alloying elements.

(5405) On the Equilibrium Diagram of System Cobalt–Tungsten Carbides. A. M. Korolkow, and A.M. Lavler, *Metallurg, 9,* No. 2, 53-55 (1934); *Met. Abstracts, 1,* 565 (1934). The limit of solid solubility of W carbide in Co is 15% and the eutectic contains 35% WC.

(5406) Investigation of Alloys Produced according to the Ceramic Process. N. M. Zarubin, and L. P. Mol'kov, *Vestnik Metalloprom., 14,* No. 7, 59-68 (1934); *Met. Abstracts, 2,* 148 (1935). Related to carbide systems. In Mo-carbide system the solid solution extends to 6% Mo_2C and the eutectic occurs at 30% Mo_2C. Co dissolves 6% TaC and the eutectic occurs at 35% TaC. The alloys of TiC-Co consist of two phases.

(5407) Constitution of Alloys as Determined by the X-Ray Powder Photography. A. J. Bradley, *Metal Ind. (London), 47,* No. 6, 611-3 (1935). The equilibrium diagrams of the alloy systems Ag-Cd, Co-Al, Fe-Al were investigated.

(5408) On Laboratory Methods of Preparing Infusible Substances and Examination of Their Radiation. L. I. Kramp, and M. A. Uriev, *Zavodskaya Lab., 4,* 1090-96 (1935); *Met. Abstracts, 2,* 680 (1935). The radiation coefficient was determined for pressed Ta carbide rods sintered at 3000° C. (5400° F.) *in vacuo,* or at 3300° C. (5970° F.) in nitrogen or argon.

(5409) Spectral Emissivities, Resistivity and Thermal Expansion of Tungsten-Molybdenum Alloys. P. N. Bossart, *Physics, 7,* 50-54 (1936). Determination of the physical properties of W-Mo alloys, containing 25, 62.5, and 87.5% W.

(5410) Crystal Structure of Beta-Titanium. W. G. Burgers, and F. M. Jacobs, *Z. Krist., 94,* 299-300 (1936). Beta-Ti, stable at 900° C. (1650° F.), has a cubic body centered structure with two atoms in the unit cell.

(5411) The System Nickel-Zinc. W. Heike, J. Schramm, and O. Vaupel, *Metallwirtschaft, 15,* 655-62 (1936). An investigation of the constitution and equilibrium conditions of the system nickel-zinc was carried out with the aid of sintered powder mixtures.

(5412) Thermal Conductivity of Tungsten. W. C. Michels, and M. Cox, *Physics, 7,* 153-55 (1936). The determination of the thermal conductivity of tungsten wire is described.

(5413) The Mutual Solubility of Carbides (in Russ.). L. P. Mol'kov, and V. V. Vicker, *Vestnik Metalloprom., 16,* No. 8, 75-88 (1936); *Met. Abstracts, 3,* 521 (1936). The mixed carbide powders are pressed and sintered at 1500-2000° C. (2730-3630° F.) and examined by x-rays. TiC forms a solid solution with up to 82.2% WC, 85% Mo_2C, 40% Cr_3C_2. WC and Mo_2C dissolve only small amounts of TiC.

(5414) Iron-Zinc Alloys. J. Schramm, *Z. Metallkunde, 28,* 203-207 (1936). Iron-zinc and iron-tin alloys were prepared from powders for an investigation of the constitution of the alloy systems.

(5415) Recovery of Cold-Worked Nickel at Elevated Temperatures. E. Fetz, *Trans. Am. Soc. Metals, 25,* No. 4, 1030-57 (1937). Electrolytic nickel powder, compressed and vacuum sintered close to the melting point, was used in the experimental work. Reference is made to the anomalous high hardness observed with hot-pressed high dispersed powder by Trzebiatowski.

(5416) Thermal Expansion of Cemented Carbides (Carboloy). P. Hidnert, *J. Research Natl. Bur. Standards, 18,* 47-52 (1937). The rates of expansion of the samples of cemented W-carbides containing 13% Co are greater than the rates for carbide with 5.9% Co. The rates of expansion of cemented carbides are greater than rates of W alone and less than rates of Co.

(5417) Contribution to the Data on Theoretical Metallurgy. K. K. Kelley, *U. S. Bur. Mines, Bull. No. 407* (1937), 65 pp. Thermodynamic data of carbides and nitrides are given; carburization or iron by methane and decarburization of chromium are discussed.

(5418) Decomposition of Supersaturated Solid Solution of Molybdenum in Iron. B.G. Livshits and L.M. Lvova, *Zhur. Technicheskoi Fiziki, 7,* No. 5, 498-500 (1937); *Met. Abstracts, 4,* 614 (1937). Hardness, coercivity, magnetic saturation of a 14.7% Mo-Fe alloy were determined after heating to 1200° C. (2190° F.) and annealing at 500-900° C. (930-1650° F.), quenching and reheating.

(5419) Structure of the Intermetallic Phases in the Systems W-Co and Mo-Co, I-III. M. M. Babich, E. N. Kislyakova and Ya. S. Umanski, *Tech. Phys. U.S.S.R., 5*, No. 3, 189-194 (1938), in English; *J. Tech. Phys. (U.S.S.R.), 8*, 119-122 (1938). Continued in *J. Phys. (U.S.S.R.), 1*, 309-313 (1939); *J. Tech. Phys. (U.S.S.R.), 9*, 533-536 (1939). In the system W-Co, two intermetallic compounds exist, WCo and WCo_3, the former having the composition closer to W_6Co_7, and crystallizing in rhombohedrons, and the latter being a compound of the superstructure type, the cell of which has hexagonal symmetry. The compound $MoCo_3$, in the system Mo-Co, is geometrically identical in all respects with WCo_3.

(5420) Recovery of Cold-Worked Nickel on Annealing. E. Fetz, *Trans. Am. Soc. Metals, 26*, No. 4, 961-996 (1938). Powder metallurgy methods and carbonyl and electrolytic powders used in the experimental work because of inherent advantages in using high-purity materials.

(5421) Polymorphic Transformation of Iron in Fe-As-Sb Alloys. V. N. Gridnev, and V. N. Svechnikov, *Metallurg, 13*, No. 1, 13-19 (1938). Alloys containing less than 4% As and 4% Sb were prepared from electrolytic Fe and As by sintering powders in Tammann furnace; C did not exceed 0.65%. The Fe-As and Fe-Sb systems have closed gamma fields.

(5422) Electrical Conductivity and Equilibrium Diagram of Binary Alloys. G. Grube, and O. Winkler, *Z. Elektrochem., 44*, No. 7, 413-28 (1938). Mo-Ni alloys were prepared from powders and the equilibrium diagram up to 80% Mo was plotted. A new intermediate phase Ni_3Mo is shown to exist.

(5423) Influence of Chromium on Oxide Resistance of Tungsten at High Temperatures (English summary). S. Isada, H. Asada, and S. Higasimura, *Rept. Aeronaut. Research Inst., Tokyo Imp. Univ., 13*, No. 7, 195-202 (1938); *Iron Steel Inst., Japan, 25*, 106-114 (1939); *Met. Abstracts, 5*, 265 (1938). Mainly from x-ray analysis a tentative equilibrium diagram is advanced for the W end of W-Cr system, which indicated a solid solubility of Cr. W is rendered appreciably more resistant to oxidation above 13% Cr. Alloys prepared from powders.

(5424) Electrical Conductivity and Phase Diagrams of Binary Alloys. System Ni–Mo. H. Schlecht, G. Grube, and H. Ploszek, *Z. Elektrochem., 44*, No. 7, 413-422 (1938). The alloys are produced of Ni carbonyl powder and Mo powder.

(5425) The System Cobalt-Zinc. J. Schramm, *Z. Metallkunde, 30*, No. 1, 10-14 (1938). A report on the production and investigation of Co-Zn alloys made from powders.

(5426) The Specific Heat of Nickel from 100 to 600° C. (212 to 1112° F.). C. Sykes, and H. Wilkinson, *Proc. Phys. Soc., 50*, 834-51 (1938). Determination made on four types of nickel, including powder product.

(5427) Constitution of Chromium-Molybdenum Alloys. W. Trzebiatowski, and H. Ploszek, *Naturwissenschaften, 26*, 462 (1938). Sintered alloys were examined. As raw material, electrolytic Cr (1% oxide content) and high purity Mo-powders were used.

(5428) Energy Loss to Gas and Rate of Vaporization of an Incandescent Wire as a Filament. W. Elenbaas, *Nederland Tijdschr. Natuurk., 7*, 77-88 (1939). Theory. Life of filament as a criterion; influence of gas pressure.

(5429) The Transition Point Diagram of Zirconium-Titanium System. J. D. Fast, *Rec. trav. chim., 58*, No. 9/10, 973-83 (1939). The alloys of Ti and Zr were prepared by thermal decomposition of mixtures of their iodides on an incandescent tungsten wire.

(5430) An Electrical Phenomenon of a Palladium Filament Occluding Hydrogen. J. Horiuti, and K. Hirota, *Proc. Imp. Acad. Tokyo, 15*, 10-12 (1939). Hydrogen on Pd-filament at 100° C. (212° F.) dissociates protons and electrons. (This phenomenon utilized in purification of H_2 by catalyzation of $O + H_2$ to H_2O.)

(5431) The Aluminum and Tungsten Equilibrium Diagram. W. D. Clark, *J. Inst. Metals, 66*, Pt. 8, 271-288 (1940). Sintered if more than 30% W. Elements are found mutually soluble up to 2%.

(5432) The Lattice Constant of Carbide and Nitrides. W. Dawihl, and W. Rix, *Z. anorg. allgem. Chem., 244*, No. 2, 191-97 (1940). The retarding of the reaction during the carburization or nitration of TiO or VO depends on the temporary formation of low oxides and their solubility in the lattice.

(5433) Properties of Hard Metal Alloys and Their Connection with Their Resistance to Wear. W. Dawihl, *Z. Metallkunde, 32*, No. 9, 320-325 (1940).

Study of the wear resistance of tungsten carbide and tungsten carbide-titanium carbide materials during cutting.

(5434) Electrolysis of Solid Solutions of Oxygen in Zirconium. J. H. De Boer, and J. D. Fast, *Rec. trav. chim., 59,* No. 2, 161-67 (1940). It is shown that the oxygen atoms are present in the interstices of the Zr lattice, and that they have great mobility in the lattice at high temperatures; the influence of an electric field is discussed.

(5435) The Nickel-Tungsten System. F. H. Ellinger, and W. P. Sykes, *Trans. Am. Soc. Metals, 28,* 619-45 (1940). The phase diagram was established on the basis of a systematic study by the methods of metallography and x-ray diffraction.

(5436) Polarization during Electrolytic Reduction of Titanium Ions (in English). O. Esin, *Acta Physicochim. (U. S. S. R.), 13,* 429-43 (1940). The cathodic curve has two branches, one of which refers to the process of transition of quadrivalent Ti to the trivalent form, and the other to the transition of the latter to the bivalent form.

(5437) Magnetic Analysis of Hard Metal. G. Ritzau, *Stahl u. Eisen, 60,* No. 40, 891 (1940). It is believed that the high coercive force is caused by the tension in the cobalt phase.

(5438) Electrokinetic Potential of Composite Membranes. M. Nisikawa, and S. Komagata, *Researches Electrotech. Lab. (Tokyo), No. 440,* 1-16 (1940). Electrokinetic potential of each type of composite membrane. Powder layers used for the membranes.

(5439) Recovery of Nickel from Cold Working on Annealing. E. Fetz, *Trans. Am. Soc. Metals, 29,* No. 1, 210-243 (1941). Study of factors responsible for the unusually wide temperature range of softening of cold worked Ni (electrolytic and carbonyl). Reference to carbonyl nickel in analysis of results. Discussion.

(5440) Some Applications of X-Ray Powder Method in Industrial Laboratory Problems. H. P. Rooksby, *J. Sci. Instruments, 18,* No. 5, 84-90 (1941). Ni-Fe alloy powder. Lattice distortion in W.

(5441) The Cobalt-Zinc System. J. Schramm, *Z. Metallkunde, 33,* 46-48 (1941). Co powder containing 0.004% Ni and 0.03% Fe, and a powdered Co-Zn alloy containing 85% Zn are pressed at 3000 atm. The compacts are enclosed in a quartz tube and sintered at 900° C. (1650° F.) for 24 hrs. No new three-phase fields are found.

(5442) The Nickel-Molybdenum System. F. H. Ellinger, *Trans. Am. Soc. Metals, 30,* 607-35 (1942). The phase diagram was established on the basis of a systematic metallographic and x-ray investigation.

(5443) The Systems Chromium-Tungsten and Chromium-Molybdenum. O. Kubaschewski, and A. Schneider, *Z. Elektrochem., 48,* 671-74 (1942). The constitution of the alloys is investigated, and wide ranges of solid solution are found in both systems.

(5444) Quenching Powdered Metal. N. J. Petch, *Metal Progress, 42,* No. 2, 233 (1942). X-ray diffraction studies required quenching of powdered alloys steels, containing 1.7% C; 2% Cr; 2½% Mn; or 2% Ni and 1% Cr, respectively. Complete retention of austenitic structure was not possible. Effect of powder grain size on the states of metastability in steels is emphasized.

(5445) The Tantalum-Carbon System. F. H. Ellinger, *Trans. Am. Soc. Metals, 31,* No. 1, 89-104 (1943). The sintered carbides Ta_2C and TaC were studied. X-ray data and metallographic and melting point determinations were made. Discussion.

(5446) Connection between the Expansion and the Properties of Metal Powders. W. Dawihl, and W. Rix, *Z. Metallkunde, 36,* No. 8, 197-200 (1944). Definition of grain deformation. Influence of porosity on the coefficient of expansion, connections between grain deformation and expansion. Tests on Cu and Co powders tabulated.

(5447) Theoretical Aspects of Hardness of Hard Substances. O. Meyer, and W. Eilender, *Ind. Diamond Rev., 5,* 58-61 (1945). A report of the publication of the same authors in *Arch. Eisenhüttenwesen, 11,* 558-62 (1938).

(5448) Diffusion in Powdered Metals. P. W. Selwood, and J. Nash, *Trans. Am. Soc. Metals, 35,* 609-15 (1945). A magnetic method, based on analysis of magnetization. Temperature curves are developed and used to follow the approach to homogeneity in copper-nickel powder mixtures.

(5449) X-Ray Investigation of Pseudobinary Systems TaC–TiC; CoC–TiC; TaC–ZrC; CbC–ZrC. A. E. Koval'skii, and Ya. S. Umanskii, *Zhur. Fiz. Khim., 20,* No. 8, 769-72 (1946); *Chem. Zentr., 118,* I, No. 1/2, 8 (1947). X-ray study of various binary carbide systems was carried out for more accurate data than are available at the present. Formation of solid solution series by carbide systems was investigated. Authors' results concerning lattice constants as function of concentrations are given.

(5450) Interaction of Monocarbides of Tungsten, Tantalum, and Columbium. A. E. Koval'skii, and Ya. S. Umanskii, *Zhur. Fiz. Khim., 20,* No. 8, 773-78 (1946). X-ray investigation of interaction of WC with TaC and CbC was conducted. Solubility of WC in TaC and CbC and solubility of TaC and CbC in WC as a function of temperature. Response of cemented carbide alloys to heat treating. Significance of results for industrial practice.

(5451) High Temperature Heat Contents of Titanium Carbide and Titanium Nitride. B. F. Naylor, *J. Am. Chem. Soc., 68,* 370-71 (1946). The thermal properties of TiC and TiN were investigated.

(5452) Quantitative Treatment of the Creep of Metals by Dislocation and Rate-Process Theory. A. S. Nowick, and E. S. Machlin, *Natl. Advisory Comm. for Aeronaut. Repts., Tech. Notes No. 1039* (1946); *J. Applied Phys., 18,* 79-85 (1947). The theory suggests the use of materials of high moduli of rigidity and therefore of high moduli of elasticity, such as W, Mo and cemented tungsten carbides as matrix material for heat resisting alloys.

(5453) Effective Permeability of Mixtures of Solids. D. Polder, and J. H. van Santen, *Physica, 12,* No. 5, 257-71 (1946). The effective dielectric constant is calculated for a material consisting of a medium in which solid particles or empty holes are packed together and in which the individual particles are assumed to be ellipsoidal.

(5454) Determination of Solubility Limit for Cobalt in Tungsten Carbide. U. S. Dept. Comm., PB. 70489 Rept. 133, 1947. Report of Krupp Widia Werke, Essen. Solubility limits are obtained by extrapolation of saturation *vs.* cobalt concentration curves.

(5455) An X-Ray and Metallographic Study of Sintered Chromium-Tungsten Alloys. H. T. Greenaway, *Council for Scientific and Industrial Research, Division of Aeronautic Structures and Materials, Note 162,* 4 pp. (Dec. 1947); *Met. Powd. Rept., 2,* No. 11, 173 (1948). A continuous series of solid solutions was found to exist when examining compacts sintered at 1550° C. (2820° F.) for one hour in hydrogen.

(5456) Electron Diffraction Study of Oxide Films Formed on Molybdenum, Tungsten, and Alloys of Molybdenum, Tungsten and Nickel. J. W. Hickman, and E. A. Gulbransen, *Trans. Am. Inst. Mining Met. Engrs., 171,* 371-388 (1947). Survey of literature; experimental procedure; method of interpretation of results on pure W, Mo, 80-20 Mo-W, 93-7 Mo-Ni. Discussion.

(5457) On the Structure of Sintered Hard Metals. R. Kieffer, *Metallforschung, 2,* 236-38 (1947). Describes a method to determine the distinctive marks of the phases of WC–TiC–Co hard metals.

(5458) The Crystal Structures of Molybdenum and Tungsten Borides. R. Kiessling, *Acta Chem. Scand., 1,* No. 10, 893 (1947). The systems Mo-B and W-B have been studied by x-ray methods, and the boride phases are discussed.

(5459) High Temperature Testing. W. E. Kuhn, *Can. Metals Met. Inds., 10,* No. 6, 27-29, 50 (1947); *Met. Powd. Rept., 2,* No. 2, 27-28 (1947). Refractory metals W and Mo are believed highly creep resistant on account of their high modulus of elasticity. Author emphasizes that fundamental data on creep are very scanty compared with amount of theoretical work published. Quotes A. S. Nowick and E. S. Machlin, *J. Applied Phys., 18,* 79 (1947) and Hume-Rothery as starting points. Creep testing is suggested as a method of investigating powder metallurgy variables.

(5460) A Contribution to the System Titanium Carbide-Tungsten Carbide. H. Nowotny, and G. Glenk, *Metallforschung, 2,* 265-69 (1947). X-ray investigation and comparison with the work of other observers.

(5461) X-Ray Investigation of Carbide Systems. H. Nowotny and R. Kieffer, *Metallforschung, 2,* 257-65 (1947). A fundamental contribution to the method of x-ray investigation of carbide systems.

(5462) Diffusion of Carbon into Tungsten. M. Pirani, and J. Sandor, *J. Inst. Metals, 73,* Pt. 6, 385-95 (1947). Experiments carried out with fused W, carburized at series of temperatures. Extent of carbide formation was determined and values of diffusion coefficient calculated.

(5463) Solid Solutions of Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3762/47 (1947). According to this report, dating from 1935, TiC and TiO form a series of solid solutions, but no Ti_2C was discovered. These solid solutions are stable up to 1700° C. (3090° F.) and may be interesting for making hard metal.

(5464) Metal Carbide Phases. Studiengesellschaft Hartmetall. F. D. Rept. No. 3808/47 (1947). A metallographic study in 1939 confirmed the presence of α_1 and α_2 phases in WC-Co hard metal. α_2 is presumed to originate from the melting of α_1 crystallites, and its white-lined inclusions to be a Co-W-C phase (ε) that gives rise to blistering. The problem is rather tentatively discussed also in relation to WC-TiC hard metal.

(5465) Metal Carbide Phases. Studiengesellschaft Hartmetall. F. D. Rept. No. 3811/47 (1947). According to this report of 1939, the ε-phase can be made visible by electrolytic etching at 0.5 volt and in 0.1% KOH for 15-48 hours.

(5466) Solubility of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3812/47 (1947). This report of 1939 shows that neither titanium carbide nor vanadium carbide are soluble in cobalt in the solid state, though at 10% VC a eutectic is formed at 1400° C. (2550° F.). Cobalt is soluble in TaC, TiC, VC and Mo_2C at most to the extent of 5%.

(5467) Solubility of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3813/47 (1947). According to this report from 1939, tungsten carbide and vanadium carbide form solid solutions with nucleation and recrystallization. This mechanism may perhaps apply also to the formation of α_2 in WC-Co.

(5468) Deformation of Hard Metal. Studiengesellschaft Hartmetall. F. D. Rept. No. 3819/47 (1947). According to this report of 1938, hard metal is not deformed under a compression of 6 tsi at 1000° C. (1830° F.). At 1100° C. (2010° F.) the deformation is less than 2%.

(5469) Tungsten Carbide Lattice. Studiengesellschaft Hartmetall. F. D. Rept. No. 3820/47 (1947). Blistering is ascribed in this report of 1939 tentatively to stresses in the WC lattice which produce migration of the carbon atoms and formation of graphite crystals. The x-ray work is very detailed and is correlated with metallographic aspects and sintering behavior. In a second report of 1943, the investigations are extended to TiC-containing hard metal.

(5470) Solubility of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3821/47 (1947). According to this report of 1939, TaC is practically insoluble in cobalt, but up to 10% Mo_2C is soluble in cobalt between 1200° C. (2190° F.) and 1400° C. (2550° F.), being less with carbon absorption.

(5471) Metal Carbide Phases. Studiengesellschaft Hartmetall. F. D. Rept. No. 3823/47 (1947). It was found in 1939 that large pores in WC-TiC hard metal originate through changes in γ_1 crystals.

(5472) Structure of Carbide Compounds. Studiengesellschaft Hartmetall. F. D. Rept. No. 3824/47 (1947). According to this report of 1939, titanium carbide and vanadium carbide do not form intermetallic compounds, but appear to be very slightly soluble in each other. The rate of solution is much lower than that of tungsten carbide in titanium carbide or vanadium carbide.

(5473) Metal Carbide Phases. Studiengesellschaft Hartmetall. F. D. Rept. No. 3834/47 (1947). The composition of the β-phase in WC-Co was investigated metallographically and a tentative Co-WC diagram established for the Co-rich portion in 1940. The effect on the β-phase of adding Cr_3C_2, Mo_2C, VC and TaC was studied. Metallographic investigations of binder phases on Ni- or Fe-rich tungsten carbide compositions. At 1000° C. (1830° F.) cobalt takes up less than 10% tungsten carbide. Effect of adding TiC on formation of β-phase in WC-Co. Fe (even as impurity) is important in the formation of the β-phase.

(5474) The System Iron-Tungsten-Carbon. Studiengesellschaft Hartmetall. F. D. Rept. No. 3839/47 (1947). Experimental investigation of the system Fe-W-C reported in 1940.

(5475) Solubility of Metals in Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3864/47 (1947). X-ray measurements in 1941 showed that Fe is soluble in TiC and VC, while Co is soluble in TiC, but not in VC. TiN does not take up Fe, and Mo_2C forms δ-phases with both Co and Fe.

(5476) Phases of Multiple Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3896/47 (1947). In WC-TiC-Co made by carburizing the mixed oxides, the γ-phase is formed only with sintering temperatures between 1540-1600° C. (2800-2910° F.) beyond which it again decomposes. Pronounced grain growth of the WC occurs. (Report dates from 1940-41.)

(5477) Phases of Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3897/47 (1947). Metallographic and x-ray tests show that the γ_1 phase is TiC or a TiC-rich constituent that has not yet reached equilibrium with the γ-phase. The development of the γ-phase controls the cutting performance. No structural changes could be detected by adding 1% VC, Mo_2C or Mo to WC-Co. (Report dates from 1938, 1940, 1941.)

(5478) Phases of Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3902/47 (1947). Aggregation of the β-phase in WC-Co points to under-sintering and can be eliminated by increasing the sintering time or temperature. In H_2, a quality containing 0.6% VC, 1% TaC, 7% Co, the β-phase was present in granular and not lamellar distribution with a very fine α_1. This effect was considered to be due to the admixed carbides. (Report dates back to 1941.)

(5479) Welding Experiments. Studiengesellschaft Hartmetall. F. D. Rept. No. 3903/47 (1947). A detailed account of the "welding experiments" with steel and carbide cubes, dating from 1941. Welding is prevented by either oxide or sulphide films.

(5480) Lattice Constants. Studiengesellschaft Hartmetall. F. D. Rept. No. 3910/47 (1947). A compilation of lattice constants for the hard carbides was made in 1942.

(5481) Part 3 Lattice Constants in Multiple Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3913/47 (1947). Further x-ray work on lattice constants in WC-TiC, TiC-Co, W-TiC, Ti-WC and WC-TiC with 5% Co was described in 1942.

(5482) Phases of Hard Metal. Studiengesellschaft Hartmetall. F. D. Rept. No. 3914/47 (1947). Metallographic studies of the δ-phase in carbon-deficient hard metal, dating back to 1938.

(5483) X-ray Measurement on Carbides. Studiengesellschaft Hartmetall. F. D. Rept. No. 3933/47 (1947). Comparative x-ray measurements on Widia, Titanit and Böhlerit were reported in 1936, 1938 together with results on various specimens of cobalt powders.

(5484) Diffusion of Cobalt in Tungsten Carbide. Studiengesellschaft Hartmetall. F. D. Rept. No. 3937/47 (1947). X-ray investigations on the diffusion of Co into WC in 1942-43.

(5485) Oxidation of Titanium and Alloys. Studiengesellschaft Hartmetall. F. D. Rept. No. 3966/47 (1947). The oxidation resistance of titanium and Ti alloys with 10% Cu, Fe, Co or Ni is discussed in two reports dating back to 1941 and 1944. Oxidation curves for the range 600-1000° C. (1110-1830° F.) were established for various hard metals, TiC-Fe, heat resisting steels, etc.

(5486) X-ray Analysis of Chromium-Molybdenum and Chromium-Tungsten Alloys. W. Trzebiatowski, H. Ploszek, and J. Lobzowski, *Anal. Chem., 19,* 93-95 (1947); *Powd. Met. Bull., 2,* No. 4, 90-92 (1947). The systems Cr-Mo and Cr-W were investigated by x-ray analysis, and melting points of Cr-Mo alloys were determined.

(5487) Principle of a Rapid Method of Producing Superstructures; Application to Alloys of the Type Platinum-Iron. L. Weil, *Compt. rend., 224,* 923-25 (1947); *Powd. Met. Bull., 3,* No. 6, 130-31 (1948); *Met. Powd. Rept., 2,* No. 1, 12 (1947). The utilization of techniques of powder metallurgy as a research tool for the study of order-disorder transformation is investigated.

(5488) X-ray Diffraction Rings from Deformed Solid Metal and Metal Powders. W. A. Wood, and W. A. Rachinger, *Nature, 161,* No. 4081, 93-94 (1947). Diffraction rings of speciments of iron are compared.

(5489) The Ternary System Tungsten-Carbide-Cobalt. L. D. Brownlee, *Met. Powd. Rept., 2,* No. 12, 185; *Oesterr. Chem. Ztg., 49,* No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 15. A series of alloys was sintered at 1350° C. (2460° F.) for various times to reach equilibrium and cooled rapidly. Results of x-ray diffraction made it possible to construct a ternary diagram with a large area which is liquid at 1350° C. (2460° F.), a very large three phase region WC + C + liquid, and an interesting series of phase fields in the tungsten-rich corner of the system.

(5490) Powder Metallurgy of Porous Metals and Alloys Having Controlled Porosity. P. Duwez, and H. E. Martens, *Trans. Am. Inst. Mining Met. Engrs., 175,* 848-877 (1948). Method has been developed by means of which porous metals and alloys having controlled permeability can be prepared; it consists of mixing porosity-producing substances with a powder mixture, and sintering at a suitable temperature. Theoretical analysis of permeability properties.

(5491) Importance of Magnetic Characteristics for Evaluation of Hard Metal Alloys. H. Franssen, *Arch. Eisenhüttenwesen, 19,* 85-9 (1948). Measurement of magnetic saturation allows determination of Co and double carbides which lead to embrittlement of hard metal; effects of sintering temperature upon linear shrinkage, electrical conductivity and coercive force of WC-Co and of WC-TiC-Co alloys; diagrams.

(5492) Corrosion Problems in Powder Metallurgy. H. Grubitsch, *Met. Powd. Rept., 2,* No. 12, 190; *Oesterr. Chem. Ztg., 49,* No. 10/11, 192 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 38. A relationship was established between the polarizability of iron powder pressings and the compacting pressure and also the previous thermal treatment of the powder. The rate of rusting depends largely on the last factor, in accordance with Hedvall's principle.

(5493) Electrical Properties of Sintered Materials. H. H. Hausner, *Oesterr. Chem. Ztg., 49,* No. 10/11, 192 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 51. Author refers to the large influence of the contact points between the particles with examples. Mixtures of first and second class conductors show no change of the electrical resistance within a fixed range of temperatures.

(5494) X-Ray Interferences with Very Great Angle of Diffraction on Mixed Crystals. H. Hendus, and H. Nowotny, *Oesterr. Chem. Ztg., 49,* No. 10/11, 184 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 66. An alloy of Cu with 24% Ni was chosen from large series of tests and investigated; a piece of that alloy was compressed at 50% and recrystallized in an evacuated tube of quartz. Discussion of results.

(5495) The System Zinc-Chromium. T. Heumann, *Z. Metallkunde, 39,* 45-48 (1948). Thermal and microscopic studies are made of Zn-Cr system with Cr up to 5%. Alloys are made by adding pure Zn powder to fused $CrCl_3$ at 400° C. (750° F.) holding for 3 hrs. and cooling slowly under a LiCl-KCl slag.

(5496) The Effect of Temperature on the Modulus of Elasticity of Pure Metals. W. Köster, *Z. Metallkunde, 39,* No. 1, 1-12 (1948). The test bars were produced from 32 pure metals, including tungsten, molybdenum and other refractory metals, precipitated from the gaseous phase and sintered. Tables give the dimensions, modulus of elasticity, and the natural frequency.

(5497) Effect of Temperature on the Modulus of Elasticity of Pure Metals. W. Köster, *Z. Metallkunde, 39,* No. 1, 145-58 (1948). Continuation of report on the determination of the modulus of elasticity for 32 pure metals..

(5498) Dependence of the Modulus of Elasticity of Binary Alloys on Its Composition. W. Köster, and W. Rauscher, *Z. Metallkunde, 39,* No. 4, 111-120 (1948). Metal carbides and nitrides are included in the tests.

(5499) Preparation and Properties of Alloys of Titanium- and Tungsten-Carbide. A. G. Metcalfe, *Met. Powd. Rept., 2,* No. 12, 184 (1948); *Oesterr. Chem. Ztg., 49,* No. 10/11, 194 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 14. Results on the evaluation of the WC-TiC component of the diagram of ternary equilibrium Ti-W-C at temperatures up to 2900° C. (5200° F.) by using metallographic and x-ray methods. (*Cf: J. Inst. Metals, 73,* 591-608 1947).

(5500) Modern Theories of Magnetism and Application. L. Néel, *Rev. Mét.*, *45*, 475-80 (1948). The fundamentals of ferromagnetism are elucidated with great simplicity, and reference is made to many well-known magnetic products at appropriate points in the argument.

(5501) Character of Interatomic Binding Forces in Phases Formed by Transitional Metals with Light Metalloids. S. A. Nemnonov, *Zhur. Tekh. Fiz.*, *18*, No. 2, 248-52 (1948). Critical evaluation of experimental data relating to the phases of the systems Cr-H, Cr-N, Cr-C, and Cr-O, and study of character of bonds between (light) metalloid atoms and atoms of chromium (and other metals) are reported. Character of interatomic binding forces is presented as depending on whether transitional metals interact with hydrogen or with oxygen.

(5502) The Structures of Carbides, Nitrides, and Oxides of Uranium. R. E. Rundle, N. C. Baenziger, A. S. Wilson, and R. A. McDonald, *J. Am. Chem. Soc.*, *70*, 99-105 (1948). The crystal structure of UC, UC_2, and U_2C_3 were determined by x-ray analysis.

(5503) Precipitation Hardening of Iron-Zinc and Cobalt-Zinc Alloys. J. Schramm, and A. Mohrnheim, *Z. Metallkunde*, *39*, 71-78 (1948). The constitution of the system iron-zinc was investigated with the aid of specimens prepared by powder metallurgy.

(5504) Transmission of Monoenergetic Slow Neutrons through Solid Solutions and Mechanical Mixtures. S. S. Sidhu, *J. Applied Phys.*, *19*, 639-41 (1948). Neutrons were passed through mixtures of TiC and WC, and also through sintered and reground solid solutions of similar compositions. The neutron scattering cross sections were determined as a function of mole per cent of WC.

(5505) Dilatometric Measurement for Studying Sintering Processes. H. Silbereisen, *Arch. Metallkunde*, *2*, No. 9, 305-08 (1948). The Bollenrath dilatometer made by Leitz was used, in which the measurement can be made also under vacuum or in a protective atmosphere.

(5506) Structure of Grain Boundaries in Metals. Ke. T'ing-Sui, *Phys. Rev.*, *73*, No. 3, 267 (1948). Activation energy of viscous grain boundary slip as determined by experiments on internal friction is compared with activation energies of volume diffusion and creep.

(5507) Heat Capacity of Hot-Pressed Beryllium Carbide Cylinder. J. B. Trice, J. J. Neely, and C. E. Teeter, Jr., *Fairchild Engine and Airplane Corp. Rept. NEPA-821*, 1948, 12 pp.; *Nuclear Sci. Abstracts*, *2*, 12 (1949). The sample was measured roughly by a radiation method in the temperature range from 600 to 900° C. (1100 to 1650° F.); the apparatus is described.

(5508) Essay on the Wear of Sintered Metals. A. Vambersky, *Oesterr. Chem. Ztg.*, *49*, No. 10/11, 189 (1948). Intern. Powder Metallurgy Conference, Graz, Ref. No. 71. The Skoda-Savin method defines wear as the volume of material rubbed off by a standardized Widia wheel. Grain size, pressing and sintering condition have an influence on the extent of wear, which also depends on chemical and electrochemical influences.

(5509) Incipient Superconductivity in Titanium. R. T. Webber, and J. M. Reynolds, *Phys. Rev.*, *73*, 640 (1948). The specimen was placed vertically in contact with liquid helium which allowed resistance measurements to be made at temperatures between 1.1 and 4.23° K.

(5510) The Structures of Uranium Borides. F. Bertaut, and P. Blum, *Compt. rend.*, *229*, 666-67 (1949). A report on the crystallography of UB_4 and UB_{12}.

(5511) The Isolation of Carbides from High-Speed Steel. D. J. Blickwede, and M. Cohen, *Trans. Am. Inst. Mining Met. Engrs.*, *185*, 578-84 (1949). Describes experiments leading to an electrolytic extraction for isolating the carbides from both annealed and hardened steel.

(5512) Experiments on the Reaction of Titanium with Oxygen and Nitrogen. L. G. Carpenter, and F. R. Reavell, *Metallurgia*, *39*, No. 2, 63-65 (1949). The paper describes results and conclusions of experiments to measure as a function of time the fall of pressure in a closed vessel containing the gas and a specimen of sintered Ti produced by the magnesium reduction process.

(5513) Lattice Parameters of High Purity Alpha Titanium and the Effect of Oxygen and Nitrogen on Them. H. T. Clark, Jr., *Trans. Am. Inst. Min. Met. Engrs., 185,* 588-89 (1949). The lattice constants of alpha-Ti are: a_O = 2.9504 A., c_O = 4.6833 A. These constants, especially the value of c_O, are increased appreciably by the addition of small amounts of O or N.

(5514) Thermionic Emission from Sintered Cathode of Thoria and Tungsten Mixture. H. Y. Fan, *J. Applied Phys., 20,* No. 7, 682-90 (1949). A theory is proposed for the mechanism of change in activity, involving the production of free thorium due to reduction of thoria by tungsten.

(5515) Penetration of Sintered Metals by Solutions of Surface-Active Agents. A. J. Finks, and N. J. Petito, *Anal. Chem., 21,* 1101-2 (1949). Porous sintered stainless steel filters are utilized for evaluating the wetting and penetrating properties of surface-active agents. The agents are not specified. The technique is employed for detection of leaks.

(5516) Thermal and Electrical Properties of Ductile Ti. E. S. Greiner, and W. C. Ellis, *Trans. Am. Inst. Mining Met. Engrs., 180,* 657-665 (1949). A report on the determination of electrical resistivity, structural transformation and thermoelectric properties of Ti.

(5517) The System Vanadium-Nitrogen. H. Hahn, *Z. anorg. Chem., 258,* 58-68 (1949). For the production of homogeneous test bars the VN powder was mixed with pure V, pressed and sintered.

(5518) Investigation of Bonding Between Metals and Ceramics. I. Nickel, Cobalt, Iron, or Chromium with Boron Carbide. H. J. Hamjian, and W. G. Lidman, *Natl. Advisory Comm. Aeronaut. Repts., Tech. Notes, 1948,* 23 pp. (1949). Bonding experiments suggested as method of indicating suitability of metal and ceramic to form ceramal for use in aircraft gas turbines; photomicrographs.

(5519) The Temperature Coefficient of Resistance of Sintered Semiconductors. H. H. Hausner, *Bull. Am. Phys. Soc., 24,* No. 1, 40 (1949). Sintered materials are to be regarded as electrical networks and the resistance between the particles are as important as the particle resistances themselves.

(5520) The Determination of the Co_7Mo_8 Phase. E. Henglein and H. Koshok, *Rev. Mét., 46,* 569-71 (1949). The authors established the existence of the Co_7Mo_8 phase from Debye-Scherer photographs of a Co-Mo alloy powder made by sintering under vacuum. The compound has a rhombohedral structure and forms a solid solution with Co.

(5521) Binary Systems. R. Kiessling, *Acta Chem. Scand., 3,* 90-91, 595-602, 603-615 (1949). X-ray investigation and establishment of the phases of Zr-B, Cr-B, and Ta-B are reported.

(5522) High Temperature Heat Contents of Vanadium Carbide and Vanadium Nitride. E. G. King, *J. Am. Chem. Soc., 71,* 316-17 (1949). The thermal properties of VC and VN were investigated.

(5523) On the Mechanism of Oxidation of Nickel-Platinum Alloys. O. Kubaschewski, and O. von Goldbeck, *J. Inst. Metals, 76,* No. 3, 255-268 (1949). The alloys were produced from nickel carbonyl powder and pure platinum; the compressed mixtures were melted in a Tammann furnace.

(5524) Measurement on Oxidation-Resistance of High Melting-Point Alloys. O. Kubaschewski, and A. Schneider, *J. Inst. Metals, 75,* No. 2, 403-416 (1949). The alloy test-pieces were made by melting the pressed powder mixture in a Tammann furnace and in a graphite electric-resistance furnace.

(5525) Oxidation Resistance and Some Phase Relationships in System Chromium-Tantalum-Nickel. O. Kubaschewski, and H. Speidel, *J. Inst. Metals, 75,* No. 2, 417-430 (1949). In the ternary system Cr-Ta-Ni the two binary phases Cr_3Ta_2 and Ni_3Ta possibly form a continuous series of solid solutions. Results of high-temperature oxidation tests are given in the range 10-40% Ta, 50-80% Ni, 10-25% Cr.

(5526) Fabrication of Titanium and Investigation of Titanium-Nickel Alloys in the Bureau of Mines Laboratories. J. R. Long, *Titanium Symposium,* Off. Naval Res., Washington, Dec. 16, 1948, pp. 27-46. Presents a tentative Ti-Ni diagram.

(5527) Tentative Titanium-Nickel Diagram. J. R. Long, E. T. Hayes, D. C. Root, and C. E. Armantrout, *U. S. Bur. Mines–Rept. Invest., No. 4463,* 1949, 13 pp. Alloys were prepared by powder metallurgy methods; it is evident that impurities present have important influence on alloys and that they cannot be considered simple binary alloys but, instead, behave more like complex ternary alloys; considerable improvement in quality of titanium will be required before high purity alloys can be supplied on substantial scale.

(5528) Structure of Diborides of Titanium, Zirconium, Columbium, Tantalum and Vanadium. J. T. Norton, H. Blumenthal, and S. J. Sindeband, *Trans. Am. Inst. Mining Met. Engrs., 185,* 749-51 (1949). Vanadium diboride was made by carbon reduction of the mixed oxides, while the others were prepared by the fused salt electrolysis; the general structure was revealed to be a triangular prism of metal atoms with a B atom at the center. Experiments on ZrB_2-TiB_2 were also made.

(5529) Solubility Relationships of Refractory Monocarbides. J. T. Norton, and A. L. Mowry, *Trans. Am. Inst. Mining Met. Engrs., 185,* 133-136 (1949). Purpose was to examine solubility of several pairs of carbides by heating them together until equilibrium was established and then examining product by x-rays; raw materials used were monocarbides of titanium, zirconium, vanadium, columbium and tantantalum, purest readily obtained commercially; results show limit placed on solubility by size factor; quantitative expression of size factor depends upon method of defining atom size. Bibliography.

(5530) Manganese-Zinc Phase Diagram. E. V. Potter, and R. W. Huber, *Trans. Am. Soc. Metals, 41,* 1001-1023 (1949). X-ray and thermal analyses were made of pure alloys prepared by powder metallurgy methods.

(5531) Heat Capacities at Low Temperatures and Entropies of VC and VN. C. H. Shomate, and K. K. Kelley, *J. Am. Chem. Soc., 71,* No. 1, 314-15 (1949). V with 8% C was intimately mixed with Norblack sufficient to comply with the formula VC, heated *in vacuo,* reground and analyzed. A table of heat capacities is given.

(5532) Heat Transfer in Sweat-Cooled Porous Metals. S. Weinbaum, and H. L. Wheeler, Jr., *J. Applied Phys., 20,* No. 1, 113-22 (1949). Heat transfer inside metals is analyzed and formulas showing temperature distributions along length of sweat-cooled bar and across sweat-cooled hollow cylinder are derived; work relates to jet propulsion requirements.

(5533) The Use of Hahn's Method of Radioactive Tracers in Powder Metallurgy. O. Werner, *Versammlung Ges. Metallkunde, Goslar, 4,* IX (1949). The occurrence of sintering is investigated with the method of O. Hahn.

(5534) Oxidation of Titanium Carbide-Base Ceramals Containing Molybdenum, Tungsten, and Cobalt. M. J. Whitman and A. J. Repko, *Nat. Advisory Comm. Aeronaut. Repts., Tech. Notes No. 1914,* 49 pp. (1949). Oxidation penetration characteristics at various temperatures and exposure periods; direct measurement metallographic method used to determine depth of penetration; metallographic study of oxidation interface and oxygen diffusion zone; ceramals are receiving particular attention for gas turbine application.

(5535) Examination of Sub-Grain Structure with the Electron Microscope. L. Delisle, and G. A. Davis, *The Physics of Powder Metallurgy.* McGraw-Hill, New York, 1951, pp. 214-229. Nucleation and recrystallization of tungsten are observed through differences in the sub-grain structure; it is shown by the electron micrographs that these differences are affected by preceeding mechanical or heat treatment of the metallic tungsten. The sizes of the blocks constituting the sub-grain structure, and their degree of disorientation within individual grains are comparable to results obtained with x-ray and other techniques.

Part 2
PATENT SURVEY

I. Production and Composition of Powders

1. GENERAL METHODS AND EQUIPMENT FOR POWDER MANUFACTURING

A. Mechanical Processes

i. Machining

(1) **U. S. 666,409** (1901). G. D. Coleman (Coleman White Lead Co.), *Comminuting Machine.* Metal is guided by rollers to a comminuting cutting tool.

(2) **U. S. 684,043** (1901). F. W. Buehne, *Comminuting Machine.* A roller with impressions is used on metal to give the desired form; the raised parts of the rolls cut or impress hollows, so that metal powder or dust is produced by means of a cutter, which is subsequently applied.

(3) **U. S. 946,551** (1910). W. Majert, *Making Powdered Tungsten or Other Hexavalent High-Fusion Point Metals.* Powdered metallic W for filaments is produced by reducing tungstic salt compounds.

(4) **U. S. 1,258,953** (1918). J. R. Simpson, *Disintegrating Meshing.* Wire mesh or cloth is disintegrated by a series of severing blades to form powdered material for bearing metal.

(5) **U. S. 1,396,108** (1921). T. Gilmore (General Briquetting Co.). *Disintegrating Machine.* Apparatus for disintegrating or shredding metal cuttings or scrap is described.

(6) **U. S. 1,415,861** (1922). I. Bing, *Machine for Reducing Turning Chips.* Turning chips are reduced by a fine grinder beneath knife rollers.

(7) **U. S. 1,420,742** (1922). R. Philipp (Magnet Werke, Eisenach). *Machine for Reducing Turning Chips.* A cutting element cooperating with a knife roller disentangles and reduces turning chips.

(8) **U. S. 1,687,886** (1928). R. Philipp (Magnet Werke, Eisenach). *Apparatus for Treatment of Waste Material.* Rotary knives in contact with stationary knives reduce difficult waste material.

(9) **Brit. 340,762** (1931). Hartstoff Metall A. G., *Powdered Iron Alloy for Magnetic Cores.* A description is given of the manufacture of Fe powder with magnetic properties from fused metal by raising the temperature of small pieces which have a larger size than the finished particles to red heat in an atmosphere free of oxygen, and then pulverizing the pieces by machining.

(10) **Brit. 362,564** (1931). Hartstoff Metall A.G., *Powdered Iron and Iron-Alloys.* Addition to Brit. 340,762. Production of Fe for magnetic cores is described. Mechanical cutting and cold working of Fe into small pieces is first performed, followed by heating in vacuum to red heat, and then in H_2, N_2 or NH_3.

(11) **U. S. 1,910,612** (1933). P. Kranz, and A. P. Schmidt (B. Wilmsen Co.), *Method of Making Metal Sponge.* A uniform sponge is made by feeding metal strands from machining operations onto a rotating member to form loops and braiding these loops.

(12) **French 758,659** (1934). I. G. Farbenindustrie A. G., *Metal Powders.* Ductile metals such as Mg are powdered by means of bands provided with steel needles that are fixed on cylinders.

(13) **U. S. 2,294,920** (1942). H. G. Lykken, *Pulverizing Machine.* Machine for pulverizing materials such as Fe chips and turnings is described.

(14) **U. S. 2,363,769** (1944). C. F. Zipper (A. G. Mather Co.), *Rotary Cutting Disk.* A description is given of a cutting apparatus for reducing such solid materials as Al and Mg by a rotary disk with a circumferentially continuous cutting face of toothed edges of a long metal saw band.

(15) **U. S. 2,368,870** (1945). J. F. Pagendarm, *Comminuting Apparatus.* A description is given of an apparatus for comminuting metals such as Mg and Al.

(16) **U. S. 2,418,990** (1947). W. M. Sheldon (Pulverizing Machinery Co.). *Chipping Machine and Impact Mill.* Billets of Al or Sn are chipped in the form of ribbonlike strips which go directly to the hammer mill and then to the pulverizing mill.

(17) **U. S. 2,431,294** (1947). F. E. Dulmage (Dow Chemical Co.). *Lathe with Rotary Cutters.* The apparatus is used for the production of unoxidized chips of a uniform size for the use in chemical processes, *e.g.*, the preparation of Grignard reagents.

(18) **U. S. 2,431,565** (1947). P. I. Klock (Aluminum Co. of America). *Comminuting Apparatus for Metal Powders.* Small metal fragments are charged into a cylindrical chamber with a rotating bladed shaft. The chamber is filled with pellets of steel while the comminuting metal fragments travel downwards.

(19) **U. S. 2,446,272** (1948). M. D. Farris, J. M. O'Connor, and R. B. Gottschalk, *Fire Extinguisher Fluid.* For burning cuttings of Mg or Al a mixture of castor oil or olive oil containing dispersed CO_2 gas is used.

(20) **U. S. 2,462,090** (1949). C. E. Galvin (Reece M. Carey). *Wool Cutting Machine and Method.* An apparatus and method for producing comminuted steel and stainless steel wool from non-ferrous metals and alloys is described. The device produces wool from thick wall drawn tubing by means of a rotary serrated cutter engaging the terminal end of the stock tube, preferably in a plane inclined to its axis.

ii. Crushing

(21) **U. S. 647,081** (1900). M. J. Fuchs, *Machine for Making Bronze Powder.* The machine consists of a series of vertically-operating beaters and means for alternately operating them, mortars with anvils at the bottom, a hopper and feeder and discharge openings.

(22) **U. S. 657,883** (1900). L. Ott, (Bronzefarbenwerke A.G.). *Process for Manufacturing Bronze Powder.* Bronze colors are produced from granular metal powder by crushing and annealing.

(23) **U. S. 681,447** (1901). M. J. Fuchs, *Machine for Making Bronze Powder.* The machine consists of a combination of a mortar having a plurality of outlets, a shield to choke the free delivery from the upper outlet, and a slide for opening and closing the lower outlet. The machine is adaptable to the production of more than two grades of powder.

(24) U. S. 1,170,888 (1916). M. J. Fuchs, *Metal Reducing Machine.* The device has an inclined runway with anvils, beaters and movable means for confining the material treated to the anvils.

(25) U. S. 1,310,526 (1919). M. J. Fuchs, *Machine for Making Bronze Powder.* A description is given of a crushing machine to make powder with beaters and anvils on the bottom of the mortar, in which the beaters are moving up and down, with means for regulating the stroke of the beaters.

(26) U. S. 1,569,484 (1926). E. J. Hall (Metals Disintegrating Co.). *Stamping Process to Make Aluminum Powder.* The disintegrating metals are covered with a lubricating liquid, having a boiling point high enough to prevent loss by vaporization during the disintegrating operation. The liquid from around and between the particles is later evaporated to produce a dry powder.

(27) U. S. 1,621,270 (1927). E. Podszus, *Apparatus for the Production of Fine Powders.* A description is given of pulverizing metals or other substances in the solid state by the action of impinging particles in rapidly circulating gas currents.

(28) U. S. 1,681,521 (1928). J. A. Daly, *Cleaning and Burnishing Metallic Powders.* By agitation with glass beads and steel particles, cleaning or burnishing is effected.

(29) Brit. 305,469 (1929). Hartstoff-Metall A. G., *Impact Pulverizing Mills.* Grinding and crushing mills have hard facings on the beaters used for pulverizing.

(30) Brit. 306,154 (1929). Hartstoff-Metall A. G., *Impact Pulverizers.* A description is given of a beater having upon its face transversely disposed abutment faces adapted to deviate laterally the particles.

(31) Brit. 318,145 (1929). Hartstoff-Metall A. G., *Impact Pulverizing Mill.* High-speed beaters, whose working faces are provided with projections adapted in combination with the contour of the inner wall to effect circulation of gas and particles are described.

(32) U. S. 1,739,052 (1929). J. H. White (Bell Telephone Laboratories). *Production of Finely Divided Metallic Materials by Mechanical Pulverization.* The metal powders are produced by incorporating them with S to make them brittle, and then mechanically pulverizing.

(33) French 702,699 (1931). Hartstoff-Metall A. G., *Manufacture of Iron Powder by Mechanical Reduction.* Fe powders are produced by reducing metal to small fragments by rolling etc., reheating in vacuum, treating with N_2, H_2, and NH_3, and reducing to powder by violent mechanical means.

(34) U. S. 1,871,450 (1932). J. A. Gann (Dow Chemical Co.), *Making Metal Powders.* Process consists of simultaneously passing a brittle Mg-Al alloy and polished Al-flakes through a crushing and pulverizing zone.

(35) German 584,453 (1933). S. Weber, *Crushing of Soft Metals.* Several Pb plates are vertically put together in a holder, connected with the casing of a roller whose teeth take away the material of the narrow edges of the plates.

(36) Brit. 403,888 (1934). I. G. Farbenindustrie A. G., *Reducing Ductile Metal Such as Magnesium to Powder.* Solid metal such as Mg is crushed with the aid of strips of cotton, leather or rubber which are provided with steel pins and coiled on rollers.

(37) U. S. 2,087,806 (1937). F. McCune, *Method and Apparatus for Separating Metallic Articles.* Irregularly shaped metallic scrap is disintegrated by sets of rollers at varying speeds.

(38) French 859,148 (1940). E. Junker, and W. Leitgebel, *Crushing of Metals.* Al scrap is heated to the range of brittleness and then crushed.

(39) U. S. 2,259,457 (1941). W. A. Groll, *Pulverizing Metal Such As Stainless Steel.* Metals are pulverized by crushing them and carrying away the particles in a water solution containing saponin and a material that can be converted into a dextrose.

(40) Brit. 564,404 (1944). J. H. Onions, *Crushing Machine.* A machine for crushing diamonds to size retained on a screen of 0.001 in. consists of a ram and an anvil carried by a table vibrated continuously; the movement of the ram is limited towards the anvil, and the ram is surrounded by a guard, to permit the passage of particles not greater than required.

(41) Brit. 567,832 (1945). Powderloys Ltd., and E. M. Trent, *Percussion Mortar.* A device for crushing sintered hard metals consists of an anvil with a hemispherical recess and co-operating with a sphere with a radius smaller than that of the recess, and a member for receiving and transmitting percussive blows above the sphere.

(42) U. S. 2,392,019 (1946). E. L. Wiegand (Orefraction Inc.), *Processing of Materials.* Attrition grinding, crushing and separation of materials, including metals, is effected by projecting a stream of fluid and material particles moving at high speed against an anvil or against a counter-stream of particles.

(43) Brit. 595,510 (1947). Standard Telephones & Cables Ltd., *Manufacturing Finely Divided Magnetic Material.* The powdered material is produced by adding an embrittling agent to the molten material, pouring it out into a mold of such size and shape that the ingots are cooled rapidly, and a fine grained crystalline structure is produced; breaking the ingot to fragments, reheating them to the recrystallization temperature and rapidly cooling.

(44) U. S. 2,441,613 (1948). L. Balassa, *Apparatus for Pulverizing Material.* An apparatus for pulverizing solid materials and simultaneously chemically reacting them at high temperature comprises a combustion chamber, a relatively shallow circular vortex chamber, and a reaction chamber, axially communicating therewith. As an example, coarse Fe oxide ore is converted to metal.

(45) U. S. 2,478,733 (1949). F. J. Wright (The Jeffrey Mfg. Co.), *Reversible Swing Hammer Crusher.* A power-driven reducing rotor and a reducing grate are mounted on arms for bodily movement about parallel axes to and from the rotor, and means for changing the angular position of the grate are provided for.

iii. Milling and Solids Disintegration

(46) German 233,164 (1911). J. S. Fasting, *Vibratory Ball Mill.* The drum of the ball-mill is shaken by an unbalanced driving member in connection with a spring suspension of the drum.

(47) Brit. 109,258 (1918). Metals Disintegrating Co., *Metal Powder Manufacture.* Mechanical grinding of metals is effected while they are covered by oil, wax, etc., to prevent oxidation.

(48) Brit. 183,134 (1923). E. Podszus, *Production of Powders of Great Fineness.* The particles are suspended in air, gas, or liquid, which is caused to circulate continuously in the form of two opposed aligned streams from the opposite sides of the casing, so that the constant pounding of the particles against one another produces the pulverization.

(49) German 387,995 (1923). Plauson's Forschungsinstitut. *Method of Dry Milling of Solid Materials.* A method of dry milling solid materials in hammer mills whose agitating members are rotating at 1000 r.p.m. in a vacuum produces particles as small as 0.008 mm.

(50) U. S. 1,444,870 (1923). Y. Fujita, *Metallic Leaf.* A metallic leaf is coated with molten adhesive powder and then ground to powder.

(51) U. S. 1,465,941 (1923). E. K. Hill, *Machine for Granulating Turnings.* Cast-off scrap metal is reduced to chips by a grinding mill.

(52) German 395,075 (1924). Hartstoff-Metall A. G., *Rounding of Particles.* Particle faces are rounded by using a propeller of special shape in a powder mill whose blades have working faces provided with projections in combination with the contour of the inner wall to effect axial flow circulation of gas and particles.

(53) German 400,307. (1924). Hartstoff-Metall A. G., *Method of Producing Finely Divided Powder.* A method of producing finely divided powder in the colloidal state consists of directing material in two eddy current circuits, which work towards each other.

(54) German 405,381 (1924). Hartstoff-Metall A. G., *Eddy Current Mill.* The inner surface of the grinding chamber is lined with a material which is worn off gradually during working, but which can be separated from the ground product by mechanical or magnetic means.

(55) Brit. 232,993 (1925). Hartstoff-Metall A. G., *Pulverizing Aluminum or Other Metals in Contact with Lubricants.* A description is given of a process for producing fine metallic powder wherein particles mixed with lubricant are caused to collide repeatedly against each other through the action of fluid eddies.

(56) Brit. 239,422 (1925). Hartstoff-Metall A. G., and E. Kramer, *Pulverizing Mill.* An air stream pulverizer functions by means of an unsymmetrical or swinging movement of the eddies which are effected by the application of unequal forces.

(57) German 410,514 (1925). Hartstoff-Metall A. G., *Manufacture of Metal Powders for Bronze Pigments.* Method of manufacturing metal powders for bronze colors consists of a housing filled with balls whose action by fall or shock is measured so that it is sufficient to planish the particles.

(58) German 411,238 (1925). Hartstoff-Metall A. G., *Eddy Current Circuit Mill.* An eddy current circuit mill with a closed casing is provided with a smooth, jointless wall in which the circuits are produced by propellers.

(59) German 412,197 (1925). Hartstoff-Metall A. G., *Eddy Current Circuit Mill.* A mill is provided with counter-current propellers which are arranged so that they produce asymmetrical eddy current circuits and which are loaded with unequal quantities of the material.

(60) German 412,378 (1925). Hartstoff-Metall A. G., *Mill for the Production of Fine Powders.* An eddy current circuit mill has a discharge pipe ending into the gas storage tank, so that its contents take part in the circuit.

(61) German 424,344 (1926). Hartstoff-Metall A. G., *Process for the Production of Fine Powders in Eddy Mills.* The material is milled with the addition of oils, wax, paraffin, etc., to coat the particles.

(62) German 435,147 (1926). Hartstoff-Metall A. G., *Mill for the Production of Fine Metal Powders.* An eddy mill is provided with a water-cooling system.

(63) German 439,023 (1926). Hartstoff-Metall A. G., *Automatic Release for Eddy Current Mills.* An automatic release for the charging appliance for eddy current circuit mills is switched in by the descending driving moment of the drive shaft, and is switched out if the driving moment has attained the established amount.

(64) U. S. 1,573,017 (1926). E. Podszus, *Production of Powders of Great Fineness.* The powders are produced by mutually impinging high velocity whirling currents in a closed vessel, and circulating the currents several thousand times per minute, which causes the particles to impinge upon each other.

(65) U. S. 1,596,051 (1926). E. Kramer, *Feeding Mechanism for Mills.* A feed mechanism for eddy mills supplies material to be ground so that the torque applied to propeller shafts remains the same.

(66) German 442,151-2 (1927). Hartstoff-Metall A. G., *Governor for Beating Mills.* The control is effected by switching in and out the armature of the electro magnets, which is removed by means of a spring, if the current strength descends, and which is then attracted during small intervals to the magnets.

(67) German 448,608; 450,837 (1927). Hartstoff-Metall A. G., *Mill for Production of Fine Powders.* A mill has the eddy current circuits produced by propellers composed of rods which are arranged one behind the other and so that they are forming a screw thread.

(68) U. S. 1,622,849 (1927). L. Ruprecht (Pulverizing Machinery Co.), *Micropulverizer.* Disintegration of brittle material is effected in a cylindrical chamber with a high speed rotary grinder; a feed screw and a screen forms the lower part of the cylinder to take off the powder.

(69) U. S. 1,647,249 (1927). E. Podszus, *Rounding of Metallic Powder Particles.* Metal powder particles are rounded by being milled together in a closed chamber by propellers.

(70) Brit. 300,879 (1928). Hartstoff-Metall A. G., and E. Kramer, *Improvements in Machines for Spheroidizing the Individual Particles of Metal Powders.* A mill is characterized by rapidly rotating driving arms which extend close to the wall of the casing and which catch particles of powder and project them in a short path and sharp angle against the wall.

(71) Canadian 281,198 (1928). L. Ruprecht (Pulverizing Machinery Co.), *Micro-pulverizer Operating on Impact Principle. Cf:* U. S. 1,622,849 (No. 68).

(72) German 459,595; 459,695 (1928). Hartstoff-Metall A. G., *Spheroidizing of Particles.* Spheroidizing particles is effected by using an eddy mill whose beaters, by their kinetic energy, force the particles together and against the wall of the mill.

(73) U. S. 1,671,678 (1928). E. Kramer, and E. Podzus (Hartstoff-Metall A. G.), *Eddy Mill.* The mill is similar to the one disclosed in U. S. 1,685,956 (No. 74), but has stirrer members mounted on propeller shafts.

(74) U. S. 1,685,956 (1928). E. Podzus (Hartstoff-Metall A. G.), *Whirling Mill.* The mill has oppositely positioned air propellers in a curved-walled casing.

(75) Brit. 304,152 (1929). Hartstoff-Metall A. G., *Grinding-Crushing Mill. Cf:* German 405,381 (No. 54).

(76) German 471,310; 479,337 (1929). Hartstoff-Metall A. G., *Rounding Particles.* Improvement of German 459,595 (No. 72). During the working of the coarse feed of the beaters, the particles receive an additional pressure.

(77) U. S. 1,711,464 (1929). L. Ruprecht (Pulverizing Machinery Co.), *Micro-pulverizer.* The pulverizer comprises a horizontal cylinder containing a grinder with rotating beaters, so that the beaters move upwardly across the inner end of the feed screw.

(78) German 491,924 (1930). Hartstoff-Metall A. G., *Beater Mill.* A mill is provided with counter-current beaters, furnished with ledges, which intermingle the particles of the product and gas and which generate counter-current eddys.

(79) German 511,369 (1930). Hartstoff-Metall A. G., *Manufacture of Metal Powders for Bronze Pigments.* Method for the production of metal powders, *e.g.*, bronze pigments, is characterized by a planishing drum which is charged continuously from one of the front walls, in which the air and the powder are blown in, so that the air removes those particles which are sufficiently planished.

(80) Brit. 360,142 (1931). Hartstoff-Metall A. G., *Method of Making Bronze Powders.* A method is described for making bronze powders in form of small foils or flakes in a ball mill. The foils and particles are conveyed into a sifter for separating and lubricating the separated unfinished particles during re-introduction to the milling drum.

(81) German 531,921 (1931). K. Schröter, and H. Wolff (Fried. Krupp A. G.), *Wet-Milling of Hard Metal Powder Mixtures.* A method for wet-grinding of hard metal powders employs the addition of a non-oxidizing and non-vaporizing liquid, *e. g.*, methylene-chloride.

(82) Swedish 150,995 (1931). Fried. Krupp A. G., *Wet-Milling of Hard Metal Powder Mixtures. Cf:* German 531,921 (No. 81).

(83) U. S. 1,793,096; 1,793,097 (1931). E. Kramer (Hartstoff-Metall A. G.), *Beetling Mill.* A beetling mill has converging walls that confine particles to the path of the beetling rotor, which has its face separated into vertical ledges with means for deflection.

(84) U. S. 1,793,098 (1931). E. Kramer (Hartstoff-Metall A. G.), *Beetling Mill.* A method of sifting the powdered material emerging from a beetling mill comprises conveying the material in a gas at one pressure, separating it, and classifying it in a closed space containing a gas at a different pressure.

(85) U. S. 1,798,886; 1,814,559 (1931). E. Kramer (Hartstoff-Metall A. G.), *High-Speed Beetling Mill.* The mill is characterized by a single rotating shaft with beetling members, provided on their operating faces with obliquely disposed projections, which propel the particles laterally, and which produce intersecting eddy currents. A passage of air tangential to the path of the beetling elements produces a current of air sufficient to overcome any counter air current produced by the beetling members during their rotation.

(86) U. S. 1,802,658 (1931). E. Kramer (Hartstoff-Metall A. G.), *Beetling Mill,* Construction details are given of a charging regulator for beetling mills.

(87) U. S. 1,832,868 (1931). E. Kramer (Hartstoff-Metall A. G.), *Manufacture of Foil-Shaped Metal Grains.* Spreading, flattening and smoothing of metal powder particles, *e.g.*, for use as bronze colors, is effected in a ball-mill with the aid of a current of air or indifferent gas; the strength of the current of air is regulated so that it will carry away the particles into a collector.

(88) U. S. 1,846,209 (1932). E. Kramer (Hartstoff-Metall A. G.), *Separator.* A separator for comminuted material comprises a container with a blower for producing a circulation of air and a plurality of passages in the casing for dividing the material and leading it to the outlet.

(89) U. S. 1,846,210 (1932). E. Kramer (Hartstoff-Metall A. G.), *Separator.* In a sifter, a plurality of superposed spaced oblique plates in alternating relation and of opposite obliquity are arranged a distance from the walls of the casing.

(90) German 587,574 (1933). Hartstoff-Metall A. G., *Production of Iron Powder.* Fe powder is produced from molten Fe which is disintegrated into small particles, which are annealed in an atmosphere free of O, and are then powdered mechanically. The resultant powder can be used for cores.

(91) U. S. 1,930,684 (1933). E. Kramer (Hartstoff-Metall A. G.), *Manufacturing Bronze Powders.* The powder is produced in ball mills providing for a return of the unfinished particles to the mill, by supplying to these particles, at the inlet end of the mill, an amount of lubricant through contact with a fresh supply of lubricated particles.

(92) U. S. 1,932,741 (1933). E. Kramer (Hartstoff-Metall A. G.), *Manufacturing Disintegrated Bronze Foils.* The product is manufactured by placing a quantity of balls in the mill, supplying metallic particles until the output of the metal powder rises to maximum, and then supplying more balls until the output falls to a minimum and subsequently rises to a second maximum higher than the first.

(93) U. S. S. R. 28,766 (1933). M. A. Karasev, *Ball Mill for Preparing Aluminum Powder.* Construction details of the apparatus are claimed.

(94) Brit. 430,777 (1935). Hartstoff-Metall A. G., and E. Kramer, *Apparatus for Producing Metal Powders.* A process of making metallic powder is described in which powder is carried from a pounding machine by a wind stream to a sifter; the powder is precipitated in a cyclone and is led into a polishing machine.

(95) French 778,609 (1935). E. Kramer, *Apparatus for Producing Metal Powders. Cf.* No. 94.

(96) Brit. 453,142 (1936). Hartstoff-Metall A. G., and E. Kramer, *Ball Mills and Method for Producing Metal Powders.* Bronze colors are manufactured by means of a ball mill with continuous output, stopping the rotation of the drum at intervals, weighing the drum with content and regulating the supply of untreated material.

(97) French 803,823 (1936). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Method of Grinding Hard Metal Composition.* Fragments of WC and Co are heated to 1600° C. (2910° F.) to facilitate their grinding.

(98) German 627,624; 627,625; 627,626 (1936). Metallpulver A. G., *Mill for Making Bronze Pigments.* A mill for making bronze pigments consists of a drum with falling steel balls.

(99) U. S. 2,052,426 (1936). I. V. Slade (Dorr Co.), *Method of Grinding.* A method of, and apparatus for grinding, applicable to the production of very fine metal powders, comprises wet grinding in ball mills, in which the material passes through a primary and a secondary cycle, both provided with wet classifying.

(100) U. S. 2,060,375 (1936). L. S. Ishimura, *Oxidized Lead Powder.* Structural and operative details of a pulverizing mill are given.

(101) Brit. 463,826 (1937). L. Baier, *Improvement in Plant for Preparing Metal Powder for Bronze Colors.* A stamping and polishing device with separator is described.

(102) Brit. 469,478; 469,764 (1937). English Metal Powder Co., and H. Meyersberg, *Manufacture of Aluminum and Other Powders.* A method of manufacturing metal powders comprises passing material through a ball mill (polishing drum), and adding lubricant after it has passed more than half way through the mill. The passage of the powder through the drum is regulated by means of partition-baffles adapted to obstruct the powder passage.

(103) Canadian 365,671 (1937). Canadian Bronze Powder Works and E. Kramer, *Mill for Production of Metal Powder.* Apparatus for the manufacture of bronze colors by means of a ball mill with continuous output is provided with means for weighing the drum with its contents.

(104) Brit. 481,367 (1938). H. H. Mandle, *Improvements in the Production of Metal Powders.* Bronze powders are produced in a ball mill by means of a worm conveyer with a hollow shaft to re-introduce material previously treated in the mill.

(105) Brit. 486,845 (1938). H. H. Mandle, *Production of Metal Powders.* The product of a gas-swept mill is conveyed by the gas stream to a sifter from which the insufficiently fine product is returned to the mill in a closed path with a valve device.

(106) Brit. 497,610 (1938). W. P. Williams, *Production of Composition of Metals and Metal Oxides.* The metal is reduced to finely divided filamentary form and is then milled in the presence of an oxidizing atmosphere.

(107) German 661,108 (1938). I. G. Farbenindustrie A. G., *Vibratory Ball Mill.* A vibratory ball mill operates according to the principle that the amplitude and the frequency of the vibration are tuned in such way that the time of throw of the individual bodies equals the time for one revolution of the drum, or the time for a full vibration of the entire mill.

(108) German 670,031 (1938). Metallpulver A. G., *Production of Bronze Powder.* Grains produced from molten bronze are rolled out with an addition of fat and then the flakes are stamped to powder.

(109) U. S. 2,107,279 (1938). C. W. Balke and C. C. Balke (Fansteel Metallurgical Corp.), *Production of Refractory Metals as Powder.* Powdered refractory metals are produced by hydrogenating the solid metal pieces rich in the desired refractory metal, grinding them to pulverulent form, and heating the powder to the dehydrogenating temperature while exhausting the gases.

(110) U. S. 2,136,445 (1938). E. Kramer (Metallpulver A. G.), *Apparatus Suitable for Use in the Manufacture of Bronze Powder.* An apparatus with a drum containing steel balls is described.

(111) German 677,710 (1939). Metallpulver A. G., *Apparatus for Making Bronze Powder.* A method for regulating the amount of powder which a ball-mill yields involves stopping the air-blast while the mill is in operation.

(112) German 696,935; 700,474 (1940). Standard Bronzefarbenwerke and C. Eckart, *Preparation of Glossy Metallic Powders.* Metal is ground to glossy powder by a ball-mill fitted with hammers and openings in the wall for compensation of air pressure.

(113) U. S. 2,194,026 (1940). H. H. Mandle (U. S. Metal Powders Inc.), *Pulverizing System.* The system comprises a ball mill with a conveyer to deliver raw material to an inlet port plus a gas blast connection to project the material to the mill.

(114) U. S. 2,199,191 (1940). S. Tour (United States Metal Powders Inc.), *Making Metal Flakes, Flitters or Shrode of Metals, such as Bronze or Gold Bronze.* Drops of molten or plastic metal are pressed through chilled rolls to produce flake material.

(115) U. S. 2,263,603 (1941). O. A. Ziehl (Metals Disintegrating Co.), *Flaking Lead.* A method for flaking Pb comprises producing a metallic paste by adding CO_2 to Pb, Sn or Zn in a ball milling operation to improve the leafing quality.

(116) German 717,557 (1942). H. Plauson, *Centrifugal Ball Mill.* A ball mill with centrifugal force action contains a horizontally rotating flat disk and over that a hood through which the supply pipe and a pipe for establishing a pressure below atmospheric penetrate.

(117) German 738,749 (1943). Siemens-Schuckertwerke A. G., H. Bayha, and E. Sautev, *Ultrasonic Grinder.* Grinding is performed in two stages; by use of a magnetostrictive vibrator, and then by use of a quartz vibrator.

(118) Swedish 106,923 (1943). H. H. Wolff (Aktiebolaget Hammarbylampan), *Mill for Hard Material.* The mill facings consist of hard metal particles pressed into a softer matrix.

(119) U. S. 2,327,402 (1943). W. G. Clark (Clarkiron Inc.), *Grinding Mill.* Grinding or pulverizing sponge metal in a ball mill is described.

(120) U. S. 2,360,893 (1944). T. Robinson, *Method and Apparatus for Effecting Pulverization and Dispersion.* An apparatus for effecting pulverization and dispersion of solid metal powders in aqueous or oleagenous bases comprises enclosures having spaced wall surfaces, a relatively rotable disk between the surfaces, and means for applying vibration to one of the wall surfaces.

(121) U. S. 2,387,548 (1945). E. L. Wiegand (Orefraction Inc.), *Processing of Material.* An apparatus for grinding or reducing hard metals in size to powder form suitable for abrasives is described.

(122) U. S. 2,399,705 (1946). O. A. Ziehl (Metals Disintegrating Co.), *Metallic Bronze Plate or Powder Pigments and Method of Manufacturing Same.* The specular reflectivity of metal flakes is increased by ball-milling in a special liquid and subjecting them to mechanical working.

(123) Brit. 592,954 (1947). L. Ruprecht, *Machine for Comminuting Materials.* A mill in which turnings are broken up by beaters attached to a cutting head has the latter encased by a screen through which materials are taken off.

(124) Brit. 593,777 (1947). Painton & Co., Ltd., and C. M. Benham, *Ball Mill.* A jar containing balls and charge is moved horizontally through a circular path and oscillated by a slidable connection through a fixed member which prevents rotation of the jar.

(125) U. S. 2,416,746 (1947). F. J. Gavin (Crown Cork & Seal Co., Inc.), *Tube Mill.* The mill is characterized in that the disintegrating media, *e.g.*, balls, are caused to move in a path or circuit which increases their impact, as opposed to the attritive action; the disintegrated material is discharged alone by maintaining the charge stable into the mill.

(126) Brit. 596,712 (1948). G. Haim, and H. P. Zade, *Vibratory Ball Mill.* The improvement of the ball-mill with an unbalanced driving member consists in an adjustable positioning of the out-of-balance weights.

(127) Brit. 611,583 (1949). W. H. Dickinson, *Device for Use in Grinding Pigments and Powders.* The apparatus consists of two hollow drums tapering slightly upward, the rotating inner drum being grooved. The wet material is ground by friction between the two cones.

(128) U. S. 2,464,775 (1949). W. R. Mobley (Joseph H. Adams), *Pulverizing Mill.* The casing of the mill is cylindrical and the material, *e.g.*, ore and coal, is crushed on its way from the inlet to the outlet of the mill between rollers and the side walls of the casing.

(129) U. S. 2,473,558 (1949). C. E. Wuensch, *Centrifugal Ball Mill.* An improved ball mill is disclosed for grinding ores. Means responsive to the density of the pulp flowing from mill regulate the flow of unground material and/or fluid to the mill.

(130) U. S. 2,478,467 (1949). R. F. Dore, *Drum Structure for Ring and Roll Mills.* Grinding rings are maintained on a common axis and are held against shifting in a plane transverse to the ring axis. Rings are maintained uniformly spaced apart so that fines are of predetermined size, this spacing being effected by spaced and flanged ties contacting the peripheries of the rings to hold the rings on a common axis.

(131) U. S. 2,486,477; 2,486,478 (1949). J. E. Kennedy, *Tube Mill.* The mill is characterized by a gear casing combined with a hollow trunnion for the charge or discharge of material to and from the drum in which a laminated seal is provided between the outer part of gear casing and a hollow rotatable trunnion. The seal includes an annular plate extending from the rotary trunnion and bears against a plate on the casing surrounding the trunnion.

(132) U. S. 2,488,714 (1949). G. A. Delp, *Adjustable Screen for Hammer Mills.* Within the casing, a number of supports are provided for the screen. The latter comprises three segmental sections of different mesh secured end to end to form a complete annular cylinder rotatably slidable on the casing cylinder. The screen may be easily adjusted to control the fineness of the product.

iv. Graining

(133) U. S. 15,733 (1856). J. Feix, *Granulating Metals.* Molten metal is granulated by means of a rotary motion in cold water.

(134) U. S. 143,485 (1873). C. Wood, *Apparatus for Granulating Slag and Iron.* Molten slag or cast Fe is granulated by the continual motion of water.

(135) U. S. 289,386 (1883). W. E. Case, *Method of Granulating.* Pb-Sb, Pb-Bi or non-oxidizable metal is molten, stirred until it has come to a finely divided condition and pressed to electrode shape.

(136) U. S. 336,590 (1886). D. Riker, *Process of Granulating Molten Metal.* Powdered metal alloy is produced by uniting metals and continuously agitating the combined mass.

(137) German 390,969 (1924). Chemische Fabrik Flörsheim, *Production of Metal Powders.* To a molten metal is admixed an inorganic powder the fusion point of which lies above the melting point of the metal until the cold addition has lowered the temperature of the mixture below the freezing point of the metal, whereupon the admixed material is separated from the metal grains by centrifugal or dissolving action.

(138) U. S. 1,523,624 (1925). F. Andrasek, and J. Drechsler, *Process for Producing Joint-Making Packing.* Soft metal is molten, poured into a bag of refractory sieve material; the bag is then rubbed against a warm plate so that the metal will pass through as grains.

(139) German 422,221 (1926). Hartstoff-Metall A. G., *Method for Graining Molten Metal.* The beaters are overflowed with a non-oxidizing fluid which produces a high vapor pressure, *e. g.*, tetraline, prior to the agitation of the molten metal, so that the fluid remains between the metal and beaters during the quick rotation.

(140) Jap. 93,875 (1931). T. Siomi, *Fine Powder of Metals and their Oxides.* Fused Al, Mg, Cu, Zn, Sn, Bi, Sb, or Cd, or alloys thereof are mixed with oxides and agitated in air. The fine grains obtained are easily ground to powder.

(141) U. S. 1,967,222 (1934). H. R. Arnold (E. I. du Pont de Nemours & Co.), *Granulation of Finely Divided Material.* The granulation is accomplished by adding to finely divided material, *e.g.*, Zn powder, 10-80% of a volatile liquid medium, and continuing the mixing to obtain an intimate uniform distribution until the material starts to form moist granular aggregates.

(142) French 788,358 (1935). Établissement Expert-Bezançon, *Metal Powders.* Low-melting metals are poured while molten into a vessel and agitated, thereby pulverizing them to small droplets. A reducing atmosphere is passed through, carrying a fog of metal to deposition chambers.

(143) German 620,126 (1935). W. Zeiss Chemische Fabrik G.m.b.H., and W. Zeiss, *Method of Producing Metal Powders.* A method of producing metal powders is described by which fused metals are mixed with fine granular metal in the presence of an inert gas, bringing the dispersion into a solid state by physical or chemical methods and then grinding the product.

(144) Brit. 440,768 (1936). Établissement Expert-Bezançon, *Manufacture of Metal Powders.* The manufacture of a powder from a metal, *e.g.*, Pb, comprises heating the metal in a vessel to a temperature above its melting point, but so low that the speed of oxidation is low, and subjecting it to an agitator which will pulverize the molten metal into droplets, into which an inert gas is drawn, to transport the metal mist into the depositing chamber.

(145) Brit. 443,450 (1936). W. Zeiss Chemische Fabrik G.m.b.H., *Powdered Metals.* Fused metals are mixed with sand and cooled while agitating.

(146) U. S. 2,037,672 (1936). W. Zeiss, *Method of Producing Metal Powders.* Metal powders are produced by providing a mixture of molten metal and a solid dispersing agent which is not deformed at the temperature of operation, stirring and cooling to solidify the metal in powder form.

(147) U. S. 2,134,091 (1938). J. L. Stecher (E. I. du Pont de Nemours & Co.), *Apparatus for Solidifying of Molten Metals.* Molten material is cooled by a fluid and discharged from a vibrating plate.

(148) U. S. 2,254,805 (1941). E. Junker, *Process for Separation of Metals.* Components of metal mixtures are separated by heating them to a specific temperature and subjecting them to a mechanical stress to reduce the lowest melting metal to powder.

(149) U. S. 2,280,703 (1942). R. Hart, *Process for Granulating Metals.* The metal is heated with a nonreactive liquid, beaten until granulated, and then cooled by another nonreactive liquid.

(150) U. S. 2,322,327 (1943). L. H. Timmins (Chromium Mining & Smelting Co.), *Production of Ferro Alloys.* Granulating ferroalloys to liberate gangue material by rapid chilling of the molten metal and slag product is disclosed.

(151) U. S. 2,358,068 (1944). S. Hiller, *Comminuting Low-Melting Metals by Heating and Flinging.* Various details of apparatus and operation for heating a confined portion of a body of molten metal, *e.g.*, Pb, Sn, Sb, Zn, Cd or their alloys, are given.

(152) U. S. 2,380,253 (1945). J. P. A. McCoy (Milwaukee Tool & Die Co.), *Method of Granulating Metals.* The method of granulation comprises agitation of solid metals of a melting point below 1000° C. (1830° F.), while completely concealed in sawdust, heating the mass, mixing it with silica gel, and separating the metal from the mixture.

(153) U. S. 2,398,455 (1946). C. E. Unger (American Foundry Equipment Co.), *Metallurgy.* Metal pellets are produced by subjecting molten metal in an open top vessel to forced vertical vibrations, to eject a shower of molten particles upward.

(154) U. S. 2,456,439 (1948). R. Morane, and R. Martinet, *Machine for Manufacture of Metal Grains.* The granulation comprises discharging molten metal from the melting pot in thin streams, causing them to reach the perforated bottoms of dividing rotary cups as a thin layer; the cups are subjected to an impact, while rotating, combined with the oscillatory motion of the feeding chutes.

(155) French 938,897 (1949). Soc. Générale Metallurgique de Hoboken, *Process for Granulation of Cobalt and Nickel.* The liquid metal is charged into a refractory vessel with a perforated base, and the vessel is vibrated. The size of granules is regulated by the diameter of perforations and frequency of vibrations.

v. Shotting

(156) U. S. 282,579 (1883). E. Small, *Apparatus and Process for Making Comminuted Solder.* Comminuted alloy suitable for solder is made by running molten alloy in a blast of air.

(157) U. S. 686,839 (1901). C. Bachman, *Granulated Cast Iron.* Particles of Fe for grinding and cutting stones, glass, etc., are formed by forcing molten Fe on a drum in cold water.

(158) U. S. 952,828 (1910). P. B. Martyn, and W. Airdrie, *Apparatus for Manufacture of Metal Grits.* Molten metal is forced on series of blades.

(159) U. S. 1,739,068 (1929). J. E. Harris (Bell Telephone Laboratories), *Manufacture of Finely Divided Metallic Materials.* Molten material, such as alloys of Fe, Ni and Co, is cast in water, producing a fine-grained structure, and this is pulverized.

(160) U. S. 1,780,201 (1930). D. Martin (Globe Steel Abrasive Co.), *Process for Making Metal Pellets.* Metal pellets are produced by forcing molten metal between rolls in the presence of water.

(161) U. S. 1,872,169 (1932). A.L.J. Queneau, *Process for Separation of Component Constituents, such as Cadmium.* From the fumes of Zn ore treatment, Cd (as one impurity) is removed as a metallic dust.

(162) U. S. 1,886,285 (1932). D. Martin (Globe Steel Abrasive Co.), *Production of Powdered Metal for Abrasive Material.* Molten metal is supplied to a larger stream of water at rapid rates and forms regular particles of abrasive material.

(163) U. S. 2,076,798 (1937). C. P. Teeple, *Method for Preparing Metal Shreds.* Molten metal is poured and exuded through a perforated plate of predetermined size and contour; varying sized shreds suitable for packing purposes are produced.

(164) U. S. 2,159,433 (1939). J. F. Ervin, *Method of Disintegrating Metals into Shottings.* To form powdered abrasive material, molten metal is discharged on a stream of liquid having an oily character.

(165) Brit. 519,784 (1940). S. Hiller, *Apparatus for Comminuting Molten Metal.* An apparatus for finely comminuting molten metal comprises a flinger wheel adapted to dip into and project the molten metal above the free surface.

(166) U. S. 2,252,876 (1941). W. H. Woodford (Remington Arms Co., Inc.), *Lead Manufacture.* Granulated or fibrous Pb is produced by dropping a stream of molten Pb into a solution containing Na_2CO_3, boric acid, or HCl.

(167) U. S. 2,269,528 (1942). J. L. Gallup (Radio Corp. of America), *Method of Manufacturing Metal Spheres.* A method for manufacturing small metal particles consists of dropping molten metal through space.

(168) U. S. 2,287,029 (1942). R. L. Dowdell (Regents of University of Minnesota), *Shot of Lead-Magnesium Alloy.* For making spherical shot, a molten alloy containing 0.5-10% Mg and 99.5-90% Pb is supplied to the upper surface of a perforated plate and dropped through it, and the process is effected in a hydrocarbon gas such as propane.

(169) U. S. 2,310,590 (1943). H. Marette, *Method of Forming Metal Shot.* Metal shot is formed by subjecting molten metal to a stream of water.

vi. Liquid Disintegration

(170) U. S. 99,588 (1871). W. H. Perry, *Granulated Iron.* Fe is granulated by a stream of cold water impinging upon the molten metal.

(171) U. S. 305,758 (1884). A. M. Randolph, *Process of Making Granulated Solder.* A stream of cold water is projected against a stream of molten alloy or solder.

(172) U. S. 373,766 (1886). J. B. Bosworth (New England Manufacturing Co.), *Apparatus for Granulating Lead.* A jet of steam forced on molten Pb decreases oxidation, which is present when a blast of air is used to effect the granulation.

(173) German 116,798 (1901). E. Offenbacher, *Production of Metal Grains.* The fluid metal is poured onto a rotating disc, which flings the particles into a water basin.

(174) German 147,013 (1903). Bronzefarbenwerke A. G., *Production of Metal Flakes.* The metal is poured out radially on the inner side of a drum, which takes it along until it is frozen and the leaves can be stripped off.

(175) German 158,679 (1905). L. Lauer, *Production of Metal Strips for Bronze Powder.* Molten metal is poured onto a rotating disc, so that it forms a thin spiral, which is taken off as a whole.

(176) U. S. 796,338 (1905). H. Maxim, *Pulverizing Metals.* Molten metal is poured in a stream of gas or vapor under pressure.

(177) German 180,904 (1907). F. Tischendorfer, *Production of Bronze Powder.* The powder is produced by disintegrating the liquid metal, using jets of H_2 in a chamber free of O_2.

(178) German 197,094 (1908). J. D. Miederer, *Arrangement for Production of Stamping Mass for Bronze Colors.* The rotating vessel into which the fluid metal is poured has a conical breaker plate which rotates in an opposite direction to the rotating vessel.

(179) U. S. 1,245,328 (1911). W. Freeman, *Method for Pulverizing Molten Metals.* Molten metal is forced into a hollow, inclosing jet or stream of gas, traveling at sufficient velocity to cause a break up into particles.

(180) Brit. 150,490 (1920). J. P. Mellor, *Pulverizing Metals.* Metal at a temperature just below the boiling point is poured in a thin stream upon a steam jet issuing

horizontally and elongated horizontally so as to get a flattened formation of the jet.

(181) German 422,221; 422,222 (1925). Hartstoff-Metall A. G., *Producing Grains from Molten Metal.* Method of producing grains from molten metal comprises pulverizing a stream of liquid metal through beaters rotating with high velocity and catching the particles by a fluid for retardation of their movement.

(182) Brit. 233,720 (1926). Hartstoff-Metall A. G., *Granulating Metals.* Molten metal is fed to a rotating beater in an inert atmosphere and the subdivided metal so formed is projected into tetralin, paraffin or other inert material.

(183) German 431,906 (1926). Hartstoff-Metall A. G., *Producing Grains from Molten Metal.* A method of producing grains from molten metal comprises pulverizing a stream of liquid metal through beaters rotating at high velocity, and wetting the beaters with nonoxidizing fluid.

(184) U. S. 1,573,017 (1926). E. Podszus, *Fine Powders of Metals and Other Substances.* Whirling currents of gas or air of great force and velocity are used to disintegrate Pb and Cu.

(185) U. S. 1,615,995 (1927). W. Mueller, *Apparatus.* An apparatus used for melting and pulverizing metals utilizes the action of an electric arc and a stream of compressed air.

(186) German 460,898 (1928). Hartstoff-Metall A. G., *Method of Producing Divided Metals.* A method of producing finely divided metals comprises dispersing a stream of molten metal by a large quantity of fluid drops, moving very quickly.

(187) U. S. 1,671,683 (1928). E. Podszus (Hartstoff-Metall A. G.), *Method for Producing Finely Granulated Bodies.* A jet of liquid metal is broken up and forced into layers of liquid to prevent the particles from coming in contact with each other.

(188) U. S. 1,703,634 (1929). E. Podszus (Hartstoff-Metall A. G.), *Pulverizing Metals.* Metal particles are caused to impinge on each other by opposing gas eddies; about 2% of a fatty substance is added to coat the metal particles and keep them dry.

(189) German 534,681 (1931). I. G. Farbenindustrie A. G., *Particles from Molten Material.* The particles are ejected by means of a rotating wheel dipping into the bath. Classification is effected by selecting particles ejected under the same angle.

(190) U. S. 1,856,679 (1932). H. M. Williams, and V. W. Bihlman (General Motors Research Corp.), *Apparatus for Comminuting Metals.* Molten metal is subjected to a whirling stream of aeriform fluid under pressure.

(191) U. S. 1,859,992 (1932). G. E. Seil, *Method for Subdividing Materials.* A stream of liquid metal is subjected to a stream or gas at high velocity.

(192) U. S. 1,938,876 (1933). Y. Takata, *Apparatus for Producing Pulverized Lead from Molten Lead.* An apparatus with an orifice and blades rotating at high speed is used to produce pulverized Pb.

(193) U.S. 2,047,391 (1936). J.L. Stecher, M.G. Amick, and C.E. Daniels (E. I. du Pont de Nemours & Co.), *Machine and Method for Making Solid Comminuted Materials.* Solid comminuted material is made directly from molten material by allowing the molten material to solidify on a cold surface; the material is then comminuted by rotary tools.

(194) U. S. 2,061,696 (1936). J. H. L. de Bats, *Apparatus for Making Powders.* Steel, W and other metal powders are produced by centrifuging them in the molten state, closed in a chamber under protective atmosphere.

(195) U. S. 2,062,093 (1936). G. H. Kann (Globe Steel Abrasive Co.), *Production of Powdered Abrasive Material.* Molten metal is discharged on a rotatable surface to form abrasive material.

(196) Brit. 466,537 (1937). E. I. Du Pont De Nemours & Co., *Metal Powder.* Molten material is comminuted by pouring into a space between a cooled stationary drum and rotating drum with radial tools.

(197) Brit. 497,586 (1938). Richardson Co. and A. Krauss, *Apparatus for Reducing Molten Materials, e. g. Metals, to Fine Filamentary Form.* A process for the

reduction of molten metal to a fine filamentary form comprises forcing the material centrifugally or by pressure from a two-part container through very fine passageways formed by identations in one or both of the meeting edges of the parts of the container into a cooling medium.

(198) Swedish 198,468 (1938). M. U. Schoop, *Production of Bronze Powders.* The molten metal is atomized by a jet of pressurized gas against a rotating and cooled disc with a polished surface.

(199) Brit. 510,320 (1939). Deutsche Gold- und Silberscheideanstalt, *Granulation of Metals.* By causing the melt to impinge on a rapidly rotating disc and directing a cooling agent as near as possible to the point of impingement, metal granules are formed.

(200) French 843,208 (1939). J. M. Merle, *Disintegration of Metals.* The molten metal is poured out on a quickly rotating and cooled disc, so that a thin metal skin is formed, which is then pulverized.

(201) Swedish 206,995 (1939). Deutsche Gold- und Silberscheideanstalt, *Liquid Disintegration.* Molten metal is disintegrated by quickly rotating discs and blowing cooling liquid or gas on the disc.

(202) U. S. 2,213,365 (1940). S. Hiller, *Apparatus for Producing Powder of Low-Melting-Point Metals.* Molten metal is forced over a rotatable flinger wheel.

(203) Belg. 448,226 (1942). Deutsche Pulvermetallurgische Gesellschaft m.b.H., *Production of Metal Powders.* Metal powders are produced by quickly cooling a jet of the molten metal which is heated above the fusion point and pulverized by a jet of liquid or gas which is directed under a 45° angle against the whole surface of the liquid metal.

(204) U. S. 2,271,264 (1942). E. Kaufmann and W. Truthe (Chemical Marketing Co.), *Process for the Conversion of Metals and Metal Alloys in Finely Divided Form for the Manufacture of Dental Amalgams.* A molten alloy of Ag and Sn is impinged against a rapidly rotating surface which is sprayed with cooling liquid.

(205) U. S. 2,304,130 (1942). W. Truthe (Chemical Marketing Co.), *Process for the Conversion of Metals into Finely Divided Form.* Metal powders are formed by directing a stream of fused metal in thin liquid form against a rotary disc and simultaneously directing a stream of water against the disc, the rate of feed being sufficient to effect intensive cooling of the fused material.

(206) U. S. 2,305,172 (1942). O. Landgraf (Chemical Marketing Co.), *Process for the Conversion of Liquid Substances Into Finely Divided Form.* Metal powders are formed by directing a metal stream onto a rotating surface after contact of the molten metal with the cooling liquid.

(207) U. S. 2,306,449 (1942). O. Landgraf (Chemical Marketing Co.), *Process and Apparatus for the Conversion of Molten Metals or Metal Alloys.* A process for the conversion of molten metal into fine particles of substantially uniform size, comprises impinging a stream of molten metal against a rapidly rotating beating surface and simultaneously impelling the resulting subdivided metal directly against a further rapidly rotating beating surface while supplying a stream of cooling liquid to the first rotating surface simultaneously with the stream of molten metal.

(208) German 739,743 (1943). J. Eckart, and H. Plauson, *Finely Powdered Metals.* The metal powders are produced by fusing and impinging the metal drops on a disc rotating very quickly, so that the drops are centrifuged off the disc, coming into a stream of air for discharge.

(209) U. S. 2,330,038 (1943). J. F. Ervin, *Disintegrating Molten Metals Into Globular Abrasive Particles.* The apparatus is described and details are given of the operation which involves impacting of a plurality of converging streams of molten metal.

(210) U. S. 2,341,704 (1944). J. F. Ervin, *Disintegrating Molten Metals Into Globular Abrasive Particles.* The method comprises entraining a flowing liquid in a flowing gas and discharging that mixture in form of jets, discharging a stream of molten metal into a series of these jets, to divide the molten stream into drops which solidify into round shape due to surface tension; then the expanding action of the gases released from the jets causes spreading of the metal drops which fall into a quenching medium.

(211) U. S. 2,356,599 (1944). O. Landgraf, *Process and Apparatus for Comminuting Liquid Substances.* An apparatus for comminuting liquid materials, especially molten metals, is characterized by rotary elements with radially disposed beaters arranged at an angle to the axis of the rotary elements.

(212) U. S. 2,384,892 (1945). G. J. Comstock (F.W. Berk & Co., Inc.), *Method for the Comminution of Molten Metals.* The end of a stream of molten metal is swept by solid streams of liquid at high pressure to effect disintegration into minute particles.

(213) U. S. 2,402,441 (1946). L. H. Paddle, *Reduction of Metals to Powdered or Granular Form.* An apparatus for subdividing metals consists mainly of a closed chamber with a nozzle at one end to inject a stream of molten metal, means for impinging a stream of gas against the stream of metal and means for separating the gas from the subdivided metal.

(214) U. S. 2,422,099 (1947). S. Hiller, *Apparatus for Comminuting Metals.* The apparatus comprises means for melting the metal, comminuting it to particles, separating the heavier particles and returning them to the molten metal, and means for collecting the lighter particles in the finely divided state.

(215) Brit. 597,150 (1948). F. W. Berk & Co., Inc., *Apparatus for Comminuting Metals.* A stream of molten metal is disintegrated by means of a high-pressure centrifugal spray of a liquid. The particle size is controlled by the size of the metal stream, the rate of rotation, the size and number of apertures, and the distance between the apertures and the metal stream.

(216) U. S. 2,439,772 (1948). J. T. Gow (Steel Shot Products Inc.), *Forming Solidified Particles from Molten Metal.* The molten metal falls in a stream into a dish-shaped receptacle, rotating vertically, which throws the metal from its periphery in form of small globules against a revolving and cooled container, to form a revolving wall of the liquid.

(217) U. S. 2,439,776 (1948). H. L. Klein, and J. L. Courtright (Steel Shot Products Inc.), *Forming Solidified Particles from Molten Metal.* Refers to U. S. 2,439,772 (No. 216), with the improvement of forming the particles in a continuous operation, quickly removing them from the liquid and discharging them free from liquid.

(218) U. S. 2,451,546 (1948). H. R. Forton, *Apparatus for Forming a Powder from Metals.* The molten particles of metal are introduced into a rotating drum through which they travel by means of a gas stream.

(219) U. S. 2,470,569 (1949). M. H. Meighan, and K. N. Brown (F. W. Berk & Co., Inc.), *Apparatus for Comminution of Molten Metals.* The arrangement includes a tank to receive molten metal from a crucible or ladle above it, a rotary spray near an opening supplying water under pressure of 50 psi and beneath and in juxtaposition with said spray head, and an adjustable nozzle spray which also supplies water at the same pressure. As the second spray forces the metal into the first spray, the accumulation of waste material on the sides of the tank is prevented, and a pure metal or alloy solidifies in finely divided form.

(220) U. S. 2,488,353 (1949). C. E. Unger (American Wheelabrator & Equipment Corp.), *Method and Machine for Forming Metal.* A machine for continuous production of steel shot includes means for directing a stream of molten metal against a wheel while the wheel is rapidly vibrated.

vii. Atomizing

(221) U. S. 446,986; 446,987 (1891). B. C. Tilghman, *Method of Manufacturing Chilled-Iron Globules.* Chilled Fe globules are made by atomization using high pressure steam or gas; alkali is used to prevent rust; drying is accomplished in a nonoxidizing atmosphere.

(222) German 79,993; 82,817 (1895). E. Offenbacher, *Apparatus for Manufacturing a Powdered Grinding Medium.* A stream of liquid Fe meets with a steam jet whose nozzle is adjustable.

(223) U. S. 702,736 (1902). A. F. Madden, *Apparatus for Reducing Fusible Materials to Dust.* Molten fusible material is sprayed from a rotating vessel to form a dust.

(224) U. S. 719,725 (1903). C. Bertou, *Process for Pulverizing Metals.* A liquefied metal stream is mixed with an elastic fluid, such as superheated steam at high pressure; pulverization is obtained upon sudden expansion.

(225) U. S. 720,382 (1903). W. H. Rowley, *Apparatus for Atomizing Metals.* Steam is applied to molten metal.

(226) U. S. 721,293 (1903). M. J. Fuchs (Baer Brothers), *Apparatus for Disintegration of Metals.* Molten metal is reduced to fine particles by a stream of water under high pressure.

(227) German 180,903 (1907). L. Fink-Huguenot, *Production of Powder from Molten Metal.* The fluid metal and the gas are compressed, forced together through a nozzle, so that the expansion after the escape from the nozzle will cause the atomizing of the particles. The surplus of the pressurized fluid metal is returned to a storage tank.

(228) German 180,904 (1907). F. Tischendörfer, *Method for Producing Bronze Powders.* The method consists of spraying molten metal with H_2 in a chamber free of O_2.

(229) U. S. 1,036,689 (1912). J. M. Neil, *Process and Apparatus for Atomizing Metals.* A blast of air, gas or steam under pressure is forced on a molten metal jet, and the droplets solidify before any appreciable oxidation takes place.

(230) U. S. 1,049,314 (1912). J. M. Neil, *Apparatus for Atomizing Metals.* Molten metal in a flattened condition is atomized by a jet of a heated fluid.

(231) German 264,725 (1913). The Chemical Process Company, *Method of Atomizing Molten Metal.* The method comprises atomizing molten metal pressed through a small slot, and blowing steam of a temperature equalling the melting point of the metal against the nozzle to spread a thin film of the metal on a base metal.

(232) Brit. 106,095 (1917). A. Cusquel, and H. Goupil, *Pulverizing Metal.* Atomization is effected through a central nozzle around which is an external nozzle for inert gas. The method is said to be particularly suitable for Al.

(233) French 481,904 (1917). J. W. Penicud, *Metal Powder.* Molten metal falls in thin sheets through which a jet of inert gas is blown, atomizing the metal and projecting the powder according to size.

(234) Brit. 109,257 (1918). Metals Disintegrating Co., *Pulverizing Metals.* Molten metal is atomized by a blast of steam.

(235) French 486,096 (1918). S. A. Ossidi Metallici, *Metal Powder.* Molten metal is emulsified with elastic fluid under pressure; quick release of pressure induces pulverization.

(236) U. S. 1,290,181 (1919). E. J. Hall (Metals Disintegrating Co.), *Disintegrating Metals to Dust.* A method of converting a metal (*e.g.* Zn) into a pure metallic dust free from oxide comprises bringing the metal into molten condition, with the addition of a small quantity of a metal having greater affinity to O_2 (*e.g.* Al) and then disintegrating the molten metal through atomization.

(237) U. S. 1,306,060 (1919). E. J. Hall (Metal Disintegrating Co.), *Method and Apparatus for Reducing Metals to Finely Divided Condition.* Molten metal is continuously passed through a protecting gas and then through a liquid.

(238) U. S. 1,328,446 (1920). E. Odam, *Process for the Atomizing of Molten Metals.* The method comprises producing a jet of gases by combustion under pressure and introducing the molten metal into the jet, pulverization taking place by the sudden expansion of the gases.

(239) U. S. 1,355,984 (1920). W. Lewicki (Chemical Foundation Inc.), *Process for Subdividing Metals for Use in Plastic Metallic Packings.* Molten metal and compressed air are forced against a cold metal wall.

(240) U. S. 1,501,449 (1924). E. J. Hall (Metals Disintegrating Co.), *Metal-Disintegrating Apparatus.* The apparatus comprises a tank for molten metal, a

nozzle immediately above, and means for surrounding metal issuing from the nozzle with the jet of a disintegrating fluid to lift the metal from the tank and to disintegrate it.

(241) U. S. 1,545,253 (1925). E. J. Hall (Metals Disintegrating Co.), *Nozzle Intended for Use in Disintegrating Apparatus.* A spraying gun has a nozzle of a metallic casing with a refractory lining which extends outwardly over the end of the casing, and a blast ring surrounding the casing.

(242) U. S. 1,635,653 (1927). H. M. Williams (General Motors Research Co.), *Method of Making Lead-Copper Mixture.* The two molten metals which do not alloy are mixed and atomized at a high temperature.

(243) U. S. 1,659,291 (1928). E. J. Hall (Metals Disintegrating Co.), *Process for Disintegrating Metal.* A process for producing metal powder by atomization involves disintegrating the metal by striking a stream of molten metal simultaneously and equally on all sides and on convergent angles with a rotating annular flow of a disintegrating gas.

(244) German 477,505 (1929). F. Schori, *Sprayer for Powdered Material, Especially Metal Powder.* Compressed air or gas produces a sucking action on the ground of a container, thereby lifting the powder to the atomizing nozzle in which atomization is accomplished by the compressed air, so that the powder does not come into contact with expanding gas or air.

(245) U. S. S. R. 29,767 (1929). A. A. Mikhailovskii, *Atomizing Metals.* The vapors of the liquid atomizing medium are ignited upon leaving the nozzle.

(246) German 514,623 (1930). Hartstoff-Metall A. G., *Metal Granules from Molten Metal.* Atomization is effected by dropping molten metal and by mixing a jet of gas or liquid with the falling drops.

(247) U. S. 1,834,687 (1931). J. H. Davis (Moraine Products Co.), *Manufacture of Powdered Metals.* Metal powder is produced by atomizing molten metal, hitting against a baffle and forcing a blast of air through the atomized metal.

(248) German 555,564 (1932). P. Hopf, Sr., *Apparatus.* An apparatus for producing metal dust from fused metal by atomization is described.

(249) U. S. 1,856,679 (1932). V. W. Bihlman, and H. M. Williams (General Motors Research Corp.), *Apparatus for Production of Powdered Metals by Spraying.* Copper powder is produced by spraying of the molten metal.

(250) U. S. S. R. 29,768 (1932). F. M. Isakovich, *Metal Atomizer.* Structural features are claimed.

(251) U. S. S. R. 30,107 (1932). N. P. Strezhnen, *Apparatus for Atomizing Molten Metal.* Construction details are disclosed.

(252) U. S. 1,917,523 (1933). A. D. Irons, and D. L. Waldock, *Metal Spraying Device.* A nozzle for metal spraying comprises a rear nozzle portion, having three separate passages for air, O_2 and another gas.

(253) U. S. S. R. 38,325 (1934). A. A. Abinder, *Atomizing Hard Metals.* Cementing metals or alloys are atomized into liquid low-boiling organic substances (e.g., alcohol, gasoline, etc.) to which is added not over 20% of rubber, tar or gutta-percha. Metal powder thus formed is mixed with carbides, pressed and sintered.

(254) U. S. 2,006,891 (1935). W. Hegmann, *Apparatus for Producing Metal Dust.* The apparatus produces metallic dust from molten metal by the action of an air blast in a conical vessel, so that the air is traveling towards the vertex and delivering the molten metal into the vertex.

(255) U. S. 2,040,168 (1936). J. H. L. de Bats, *Apparatus for Atomization.* An atomization apparatus contains a rotating plate for preparing powdered metals such as Fe.

(256) U. S. 2,059,230 (1936). W. K. Hall (Imperial Chemical Industry Ltd.), *Apparatus for Granulating Molten Materials.* An apparatus is described for granulating molten materials by spraying.

(257) French 812,169 (1937). H. H. Mandle, *Production of Metal Powders.* An apparatus for pulverizing metals subjects the powder to a gas current to separate

the lighter particles which are collected in a filter and conveyed to a sifter; this causes the product to be sized; the inadequately pulverized product is reintroduced into the gas stream.

(258) Brit. 481,366 (1938). H. H. Mandle, *Production of Metal Powders. Cf:* French 812,169 (No. 257).

(259) German 685,576 (1939). E. Winnicki, *Production of Metal Powder.* Molten metal is pressed through a nozzle, atomized, and cooled in reducing gases under pressure.

(260) German 685,576 (1940). E. Winnicki, and J. Geller, *Metallic Powder.* The production of metal powder from liquid metal comprises atomization of the molten metal by blowing it into a high-pressure container in which steam or inert gas is kept under pressure.

(261) U. S. 2,209,964 (1940). A. W. Ferguson (Oxides Inc.), *Reduction of Metals to a Powder.* Spraying atomization of fused Pb reduces it to finely divided particles.

(262) German 706,594 (1941). R. Backa, *Powdered Metals.* A method of producing metals and alloys in powdered form by atomization comprises melting the raw material in form of wire and pulverizing it by H_2–O_2 torch. The powder is subsequently reduced in an atmosphere such as H_2.

(263) U. S. 2,255,204 (1941). G. E. Best (New Jersey Zinc Co.), *Brass Powder.* A free-flowing brass powder of high density comprising rounded particles of brass is produced by atomizing molten brass containing 0.05-1% P.

(264) French 873,006 (1942). Deutsche Pulvermetallurgische Gesellschaft m.b.H., *Production of Fine Powders.* The fused metal is atomized by means of jets of gases or vapors which have a velocity higher than that of sound.

(265) U. S. S. R. 63,470 (1942). B. Osipow, and I. N. Ivanov, *Metal Powder by Atomizing.* A stream of liquid metal is broken up by a jet of compressed air having a whirling motion. This gives an improved atomizing effect.

(266) U. S. 2,308,584 (1943). G. E. Best (New Jersey Zinc Co.), *Atomization.* Metal powders such as Cu, Pb or Zn are produced by atomization, employing a non-convergent trough-shaped jet of gases, into which a thin stream of molten metal is directed transversely.

(267) Brit. 559,049 (1944). Telephone Manufacturing Co. Ltd. and L. H. Paddle, *Reduction of Metals to Powder or Granular Form.* Molten metal is delivered from a crucible under pressure of a gaseous fluid which is employed to effect pulverization of the metal.

(268) U. S. 2,371,105 (1945). R. Lepsoe (Consolidated Mining & Smelting Co. of Canada), *Atomizing Process for the Production of Finely Divided Metal Powders.* A fireproof method for the production of Mg and Mg alloys in powder form comprises enclosing a stream of molten metal in a flux and comminuting it by a jet of an atomizing gas.

(269) U. S. 2,380,097; U. S. 2,380,098 (1945). H. A. Doerner, *Sludge Separator.* A sludge separator is described for handling atomized mist containing metal particles and vapors of volatilized liquids produced according to U. S. 2,328,202 (1943).

(270) French 934,354 (1948). J. Baldass, *Method of Pulverizing Metal.* Two wire pistols are so arranged that the point of contact between the two wires is adjustable. At the contact point, the wires are melted by an electric arc, and the molten metal is removed by compressed air.

(271) U. S. 2,440,531 (1948). W. Zebroski. *Apparatus for Making Metal Powders.* The air nozzle for atomizing molten metal consists of a tube with a solid cylindrical-nosed insert, which gives a crescent-shaped aperture. Two nozzles are arranged at such angle that the streams of powder are further comminuted by impact.

(272) Canadian 461,125 (1949). Metals Disintegrating Co. Inc., G. E. Dunlap, and G. F. Solewin, *Apparatus for Disintegrating Metal.* The nozzle in an air-atomizing plant is provided with radiant heating means.

(273) U. S. 2,460,991; 2,460,992; 2,460,993 (1949). G. J. LeBrasse, and H. E. Francis (Federal-Mogul Corp.), *Method of Atomizing Metal, and Apparatus for Atomizing Metal.* The atomized metal is made up of particles which are spheroidal in shape, of a color equivalent to that of the freshly machined surface of the same metal when cast, and which have a bright shiny luster. The alloy consists of Pb, Ni, Sn, Zn, P, and Cu.

B. Physical Processes

i. Vaporizing and Condensing, Sublimation

(274) U. S. 706,475 (1902). E. Pohl, *Method of Producing Metals in a Finely Divided State.* Material is molten, sprayed into a retort, evaporated and condensed.

(275) U. S. 1,298,722 (1919). S. Huldt (Norsk Elektrik Metalindustri), *Method of Refining Volatile Metals.* It comprises introducing metal to be refined in a molten condition into an electric radiating furnace out of contact with air, exposing the surface of the metal bath formed to radiating heat, and exhausting the metal vapors for condensation.

(276) Brit. 158,740 (1921). W. P. Heskett, *Alloy.* Liquid alloy of Fe, Mn, Cu, Sb, Sn, Zn, Pb, Al and Bi decomposes into powder on cooling.

(277) U. S. 1,436,983 (1922). R. B. Finn, *Production of Metallic Dust.* It comprises vaporizing the metal in a retort and condensing it in N.

(278) Brit. 208,443 (1923). The Alloys Co. and W. J. Mellersh-Jackson, *Process and Apparatus for the Manufacture of Metal Dust.* Metal dust is obtained by condensation in the presence of a limited supply of an oxidizing agent.

(279) U. S. 1,456,035 (1923). M. H. Newell (The Alloys Co.), *Metal Dust and Process of Making Same.* Method comprises vapor condensation in the presence of O_2.

(280) U. S. 1,495,961 (1924). M. H. Newell and E. Anderson (International Precipitation Co.), *Obtaining Metals in Powdered Form.* Method comprises condensing the vapors of a metal such as Zn by bringing them in contact with a cooler gas containing an oxidizing constituent; the gas is used in cyclic operation.

(281) Swedish 59,721 (1925). H. G. Flodin and E. G. Gustavsson, *Production of Volatile Metals.* Ground Zn ore containing sulfides of volatile metals are mixed with Fe powder, pressed to briquettes, heated to a temperature at which the metals will give off the S content to the Fe, and then are distilled off.

(282) U. S. 1,524,101 (1925). M. H. Newell (The Alloys Co.), *Process and Apparatus for Manufacturing Metal Dust.* Method comprises vaporizing the metal and condensing the vapors in the presence of a limited and regulated supply of O, then collecting the metal dust free from the droplets.

(283) U. S. 1,566,913 (1925). M. H. Newell (The Alloys Co.), *Apparatus for Manufacturing Metal Dust.* Still and condensing chamber for manufacturing metal dust from Zn or similar metals are claimed.

(284) U. S. 1,596,979 (1926). V. Kohlschuetter, *Producing Metal Oxides or Other Solid Substances in Finely Divided Form.* Metals such as Sn, Bi etc. are vaporized in finely divided form in an air current and electrically precipitated.

(285) U. S. 1,622,433; 1,622,434 (1927). R. B. Finn (John Finn Metal Works), *Apparatus for the Production of Metal Dust.* It consists of a condenser with a movable blade.

(286) U. S. 1,794,585 (1931). J. R. Cain (Richardson Co.), *Floating Metal Powders.* Metal powder such as Fe is treated with a volatile oily liquid, and, after this is vaporized, is deposited on an aqueous solution of a metal salt

such as a Cu-salt solution, the metal of which will be replaced by the metal powder, with the resulting powder being consolidated to foil.

(287) Brit. 413,526 (1934). Standard Telephones & Cables, Ltd., *Powdered Alloys.* Preparation of a powdered alloy is accomplished by evaporating and reducing Fe and Ni-chlorides with H.

(288) French 783,887 (1935). Magnesium Products Inc., *Distilling Metal Powder.* Distillation of metal powders such as Zn or Mg is obtained, by heating the powders by radiation before their entrance into the zone of vaporization, which occurs in an inert atmosphere.

(289) U. S. 1,994,358 (1935). L. S. Holstein and P. M. Ginder (New Jersey Zinc Co.), *Purification and Separation of Metals.* Method consists of subjecting flowing stream of vapors of metals to intimate counter-current contact with a refluxing condensate formed from vapors containing metals with different boiling points. Recovery of vapor and molten metal occurs separately.

(290) U. S. 2,130,886 (1938). F. R. Kemmer (Magnesium Products Inc.), *Distillation of Metal Powders.* Method of distillation of metal powders such as Zn or Mg to recover purified metal therefrom comprises removing the gases from the powder, moving the powder into a zone of a temperature above the vaporization point, vaporizing the metal, and recovering the vapors.

(291) German 678,799 (1939). E. Maier and E. Maier, *Method for the Production of Very Fine Powders from Metals.* Metals in the colloidal state are sprayed out through nozzles so that the jets close electric current circuits and form resistors for their evaporation.

(292) Brit. 519,624 (1940). J. M. Merle, *Powdered Metallic Products.* Powder of solidified metallic particles is derived from molten metal in which the particles were spontaneously crystallized from a metastable undercooled state at a predetermined temperature below but close to the freezing point of the metal.

(293) Brit. 519,932 (1940). J. M. Merle, *Making Products Derived from Molten Metal.* Particles are derived from molten metal by forming a thin film of molten metal on a moving supporting surface and undercooling the moving film to a metastable state at a predetermined temperature below freezing point of the material to form particles which crystallize spontaneously.

(294) U. S. 2,207,746 (1940). R. Maier (Elektro-Metallurgische Apparatebau A. G.), *Apparatus for Converting Metals and The Like.* Vaporization apparatus consists of an electric furnace with an even surface allowing the formation of heap- or pond-like accumulations of the particles to be treated.

(295) U. S. 2,265,180 (1941). R. Maier (Elektro-Metallurgische Apparatebau A. G.), *Process for Converting Metals and The Like.* Vaporizing metals to produce finely divided material is accomplished by forming individual drops in a vaporizing chamber which is heated so high, that vapor is formed around a drop as soon as it is fed onto the refractory surface.

(296) U. S. 2,304,469 (1942). R. Maier (Elektro-Metallurgische Apparatebau A. G.), *Apparatus for Converting Metals.* Apparatus for converting metals and metal powders into the vapor state comprises an inclined tubular annulus encircling one leg of a transformer and forming the secondary winding, the lower arc forming a vaporizing and heat radiating surface and the upper arc forming a second heat radiating surface.

(297) Belgian 449,142 (1943). N. V. Philips' Gloeilampenfabrieken, *Deposition of Metal Powder Separated by Insulating Material.* The insulating material, *e.g.* polystyrene, runs through a vaporization vessel, and against the surface is blown a jet of metal vapor, *e.g.* Zn-Sn-Bi-Pb alloy.

(298) U. S. 2,312,811 (1943). H. Gentil (Alloy Process Ltd.), *Distillation of Metals.* Recovering pure metals by distillation and condensation in furnace is claimed.

(299) U. S. 2,330,142; 2,330,143 (1943). L. M. Pidgeon (Dominion Magnesium Ltd.), *Method and Apparatus for Recovering Volatizable Metals.* Recovering volatilizable metals by thermal treatment of metal-containing materials is claimed.

(300) U. S. 2,336,138 (1943). A. J. van Hoorn, and G. Thurmer, *Vaporization of Metals.* Vaporization of metals comprises mixing and heating metal powders with a refractory binder and applying them to a core between turns of a spacing helix.

(301) Brit. 562,108 (1944). W. F. Chubb, and E. P. Chubb, *Apparatus for the Condensation of Metallic Vapors.* Metallic vapor is caused to mix with vapor from the same metal boiling at low pressure, and is directed against a cooled surface upon which it condenses.

(302) Brit. 564,651 (1944). Standard Telephones & Cables Ltd. and W. E. Laycock, *Metal Dust.* Metallic dust is produced by heating a fine grained metal or alloy, such as Ni-Fe-Mo alloy, to temperature of recrystallization, rapidly cooling in cold-water bath, and finally reducing it in grinding mill.

(303) U. S. 2,424,512 (1947). R. A. Stauffer (National Research Corp.), *Production of Alkali Earth Metals.* They are produced by distillation from their silicate and phosphate ores with lime in excess, to displace the oxide of alkali earth metal from the ore.

(304) Canadian 448,452 (1948). P. R. Mallory & Co., Inc., F. R. Hensel, and E. I. Larsen, *Metal Evaporation.* A small amount of Li (up to 1%), and Pt (up to 20%) are added to Cu or Ag, to overcome the failure of Ag or Cu to wet a tungsten filament sufficiently, to cling to it in the vaporization process.

(305) U. S. 2,456,918 (1948). H. Church (Permanente Metals Corp.), *Distillation of Volatilizable Metals.* Method comprises supplying at least the major portion of heat of the vaporization of the metal by means of a preheated inert gas, by adding the mixture of metal and impurities in powdered form to the preheated gas, to form a suspension of solids in the gas, in which the metal at thermal equilibrium exerts a partial gas pressure causing a turbulent flow.

(306) U. S. 2,456,935 (1948). H. F. Fisher (Permanente Metals Corp.), *Refining of Volatilizable Metals.* Method comprises supplying the heat of vaporization to a bed of agglomerates by means of a preheated inert gas, passing through the bed for vaporizing the metal from the mixture, and bringing it into the gas stream.

ii. Thermal Decomposition (including Carbonyl Production)

(307) U. S. 455,227 (1891). L. Mond, *Process of Making Compounds of Nickel and Carbon Monoxide.* $Ni(CO)_4$ is obtained by exposing a surface of Ni to CO and, when action ceases, heating Ni to 350° C. (660° F.) in H_2, CO or hydrocarbon; after cooling Ni is treated with CO as before.

(308) Brit. 9300/1902 (1902). T. Dewar, *Manufacture of Nickel Carbonyl.* CO is passed under pressure over heated Ni and the Ni-carbonyl formed is condensed and separated from the excess of CO.

(309) U. S. 815,717 (1906). C. Langer (Mond Nickel Co. Ltd.), *Process of Treating Nickel Ores.* $Ni(CO)_4$ is formed by passing CO over heated finely divided Ni.

(310) Brit. 244,895 (1925). Badische Anilin- & Soda-Fabrik, *Iron Carbonyl.* Production of $Fe(CO)_5$ from H_2-reduced Fe is claimed; product can be decomposed to metallic Fe.

(311) German 407,085 (1925). Badische Anilin- & Soda-Fabrik, *Separation of Metal Carbonyls from Gases.* The gases are contacted with porous C impregnated with chromic acid.

(312) German 407,951 (1925). N. V. Philips' Gloeilampenfabrieken, *Production of Ductile Bodies of Refractory Metals.* A single crystal of the refractory metal, *e.g.* W, is heated in an atmosphere of a dissociable compound of the same metal, *e.g.*, WCl_2, to precipitate the liberated metal on the crystal which is built up thereby.

(313) French 607,134 (1926). Badische Anilin- & Soda-Fabrik. *Production of Iron Carbonyl.* CO is agitated under high pressure and elevated temperature while reacting on Fe particles.

(314) French 629,521 (1927). I. G. Farbenindustrie A. G., *Production of Metals or Alloys.* The production starts from metal carbonyls which are decomposed in a closed vessel under high pressure.

(315) German 447,130 (1927). I. G. Farbenindustrie A. G., A. Mittasch, C. Müller, and L. Schlecht, *Method of Producing Iron Carbonyl.* CO, under high pressure, streams at about 100-200° C. (210-390° F.) above or through Fe, which is produced by reduction of Fe oxides, at a velocity sufficient so that the carbonyl formed is removed by the gas stream.

(316) German 447,466 (1927). I. G. Farbenindustrie A. G., *Production of Iron Carbonyl.* The carbonyl is made by agitating Fe with low velocity CO in a reaction vessel which is connected with a deep-cooled receiver.

(317) German 448,036 (1927). I. G. Farbenindustrie A. G., *Production of Iron Carbonyl.* The carbonyl is made by agitating Fe with CO under high pressure and at elevated temperatures whereby the gases are cooled before the pressure is reduced to condense the carbonyl and to prevent decomposition.

(318) Brit. 284,087 (1928). I. G. Farbenindustrie A. G., *Extracting Metals.* Improvement of process of Brit. 269,677 (No. 817) employs Co-, Ni-, Mo-carbonyl instead of Fe-carbonyl, in making the respective metal powders.

(319) Brit. 300,691 (1928). General Electric Co., J. F. Jackson, and L. D. Goldsmith, *Metals By the Carbonyl Process.* Thermal decomposition of metal carbonyls, such as those of Ni and Fe, occurs in a vessel maintained at temperatures below their decomposition temperature.

(320) Brit. 301,778 (1928). I. G. Farbenindustrie A. G., *Metal Carbonyls. Cf:* French 652,594 (No. 322).

(321) Canadian 284,972 (1928). I. G. Farbenindustrie A. G., L. Schlecht, and E. Keunecke, *Metal Carbonyls.* Scrap Fe is heated to 600° C. (1110° F.) and subjected to the action of air and steam until completely transformed into Fe_2O_3, then reduced with H_2 at 450-500° C. (840-930° F.) and thereupon treated with CO, resulting in the formation of Fe carbonyl.

(322) French 652,594 (1928). I. G. Farbenindustrie A. G., *Metal Carbonyls.* The process consists in first oxidizing the metals, then reducing them, and repeating this treatment before acting thereon with CO. Examples are given of the preparation of the carbonyls of Ni and Fe.

(323) U. S. 1,659,205 (1928). E. A. Lederer (Westinghouse Lamp Co.), *Method of Producing Refractory Metals.* It consists of heating a sulfide of a refractory metal *in vacuo* to the decomposition temperature and removing the volatilized S.

(324) French 671,320 (1929). I. G. Farbenindustrie A. G., *Production of Metals.* It is based on decomposition of their carbonyls, by combining the CO and CO_2, freed during the decomposition, to the impurities.

(325) French 677,548 (1929). I. G. Farbenindustrie A. G. and E. Keunecke, *Production of Metal Carbonyls.* The reaction takes place in the presence of liquids or melts with low vapor pressure.

(326) French 677,858 (1929). I. G. Farbenindustrie A. G., *Metal Powders.* Method of production comprises grinding powders, obtained by decomposition of metal carbonyls, in reducing atmosphere.

(327) French 33,951 (Addn.) (1929). Badische Anilin- & Soda-Fabrik, *Cobalt Carbonyl.* Addition to French 607,134 (No. 313). In the preparation of Co-carbonyl by the action of CO on Co under pressure, the carbonyl is separated from the reaction gases by cooling before expansion.

(328) Brit. 334,976 (1930). I. G. Farbenindustrie A. G., *Metal Carbonyls.* Manufacture of metal carbonyls takes place in a plurality of separate reaction chambers and passing at least one of the reacting materials wholly or in part through two or more vessels in series.

(329) Brit. 336,007 (1930). I. G. Farbenindustrie A. G., *Finely Divided Metals From Carbonyls.* Thermal decomposition of metal carbonyls occurs in a hot free space by heating the vessel mostly from outside and partly from the interior.

(330) French 690,991 (1930). I. G. Farbenindustrie A. G., *Finely Divided Metals.* In the decomposition of carbonyls, heat is supplied partly from outside

through walls of the furnace and partly from an internal source.

(331) French 691,100 (1930). I. G. Farbenindustrie A. G., *Metal Carbonyls.* Substances containing metals are reduced with liquid or solid agents and then treated with CO to form carbonyls.

(332) French 691,243 (1930). I. G. Farbenindustrie A. G., *Finely Divided Metals.* Method comprises decomposition of carbonyls in a heated vacuum, with a whirling motion imparted to the metal particles.

(333) French 691,993 (1930). I. G. Farbenindustrie A. G., *Metal Carbonyls. Cf:* Brit. 334,976 (No. 328).

(334) German 490,439 (1930). N. V. Philips' Gloeilampenfabrieken, *Production of Ductile Bodies.* Addition to German 407,951 (No. 312). The atmosphere contains, besides the metal compound, N_2 with a pressure of 1 atmosphere.

(335) German 491,855 (1930). Chemische Fabrik von Heyden A. G., *Purification of Iron Carbonyls.* The distillation occurs in the presence of a liquid, whose boiling point must be so low that the Fe-carbonyl will not decompose.

(336) German 499,296 (1930). I. G. Farbenindustrie A. G., A. Mittasch, M. Müller-Cunradi, and A. Pross, *Iron Carbonyl.* It is produced under exclusion of oxidizing or reducing gases by agitating sponge Fe under pressure with CO at 100-250° C. (210-480° F.). Compressed sponge Fe of an apparent density of 1.5 g/cc. may be used.

(337) German 505,211 (1930). I. G. Farbenindustrie A. G., C. Müller, and E. Keunecke, *Production of Cobalt Carbonyl.* Crude Co is agitated with CO under pressure and at elevated temperatures, and the gases are cooled before the pressure is reduced to prevent decomposition.

(338) German 515,464 (1930). L. Schlecht, and E. Keunecke (I. G. Farbenindustrie A. G.), *Metal Carbonyls.* Method of producing metal carbonyls comprises performing the reduction of the metal compounds at 500° C. (930° F.) and quickly cooling the reduced material.

(339) U. S. 1,759,661 (1930). I. G. Farbenindustrie A. G., C. Müller and W. Schubardt, *Finely Divided Metals from Metal Carbonyls.* Method consists of decomposition of carbonyls of metals having an atomic weight higher than 56 in the hot free space of a heated vessel at a distance from its hot walls.

(340) U. S. 1,776,920 (1930). A. Mittasch and M. Müller-Cunradi (I. G. Farbenindustrie A. G.), *Iron Carbonyl.* The stability of Fe-carbonyl is increased and it is rendered less inflammable by adding to it a suitable proportion of an organic solvent such as heavy gasoline, which is inert to the carbonyl.

(341) Brit. 363,146 (1931). I. G. Farbenindustrie A. G., *Apparatus for Manufacture of Metals from Their Carbonyls.* Method permits carbonyls to be decomposed in vertical vessels of sufficient width to avoid contact of the carbonyls with the hot walls.

(342) French 708,260 (1931). I. G. Farbenindustrie A. G., *Metal Carbonyls.* Production of carbonyls of W or Mo comprises agitating them with CO, after a preliminary reduction treatment with an addition of powdered Fe or Cu.

(343) French 708,379 (1931). I. G. Farbenindustrie A. G., *Molybdenum Carbonyl.* Mo or material containing Mo is treated with CO under pressure at a temperature between 275-300° C. (525-570° F.).

(344) French 709,381 (1931). Mond Nickel Co., Ltd., *Nickel Carbonyl.* The speed of formation of $Ni(CO)_4$ by the action of Co on Ni is increased by the presence of a compound containing S, Se or Fe in an active form, such as Ni- or Co-compounds.

(345) French 715,206 (1931). I. G. Farbenindustrie A. G., *Production of Metal Carbonyls.* Production of necessary CO during reduction of metal is disclosed.

(346) French 717,568 (1931). I. G. Farbenindustrie A. G., *Metals From Carbonyls.* Finely divided metallic carbonyls fall through a heated chamber in process disclosed.

(347) German 517,831 (1931). I. G. Farbenindustrie A. G., L. Schlecht, W. Schubardt, and E. Keunecke, *Production of Iron Carbonyl.* It comprises reduction with ash-free solids or fluids.

(348) German 518,387; 524,963 (1931). I. G. Farbenindustrie A. G., A. Mittasch, and C. Müller, *Iron Carbonyls.* Improvement of German 499,296 (No. 336) comprises using instead of sponge Fe other Fe masses which are not reduced in the vessel, in which the formation of Fe-carbonyl takes place.

(349) German 518,781 (1931). I. G. Farbenindustrie A. G., A. Mittasch, and L. Schlecht, *Metal Carbonyls.* The metals are mixed and agitated with CO in the presence of fluids or easily melting products.

(350) German 520,220 (1931). I. G. Farbenindustrie A. G. and L. Schlecht, *Metal Carbonyls.* The material is mixed with fluids or easily melting products, then agitated with CO and heated so that the fluids will be vaporized during the reaction.

(351) German 520,221 (1931). I. G. Farbenindustrie A. G., W. Gaus and L. Schlecht, *Metal Carbonyls.* Improvement of German 518,781 (No. 349) comprises dissolving CO in the fluids or easily melting products before they will be brought into the reaction chamber.

(352) German 520,852 (1931). I. G. Farbenindustrie A. G., *Metal Carbonyls.* They are produced by agitating the metals with easily melting products which can readily be removed later from the reaction chamber.

(353) German 523,601 (1931). I. G. Farbenindustrie A. G., *Metal Carbonyls.* The solution of the metal carbonyls will be made more durable by addition of aldehyde or ketone or other acid organic compounds.

(354) German 531,402 (1931). I. G. Farbenindustrie A. G. and M. Naumann, *Molybdenum Carbonyl.* Mo or material containing Mo is treated with CO under pressure at a temperature of 275-300° C. (525-570° F.).

(355) German 531,479 (1931). I. G. Farbenindustrie A. G. and M. Naumann, *Metal Carbonyls.* Process provides for the carbonyls to flow out of the agitating chamber under pressure, together with the dissolved gases, by reducing the pressure in several steps.

(356) German 532,534 (1931). I. G. Farbenindustrie A. G., W. Gaus, L. Schlecht and M. Naumann, *Metal Carbonyls.* The CO gas current passes through several furnaces, filled with the material for the carbonyl formation, and the removal of the metal carbonyls takes place only from the last furnace.

(357) German 535,437 (1931). I. G. Farbenindustrie A. G., *Metal Carbonyls.* The metal compounds which, without primary treatment, are mixed with material which facilitates the reaction, such as Cu, are agitated with CO under pressure.

(358) German 542,783 (1931). General Electric Co. Ltd., *Metal Powders.* Method and apparatus are disclosed for the decomposition of carbonyls by hot gases which provide for a vessel whose walls are cooled to a temperature below the temperature of decomposition.

(359) U. S. 1,805,199 (1931). G. Alleman (Sun Oil Co.), *Preparation of Colloidal Metal.* The method of preparing colloidal metal, suitable for introduction into cylinders of internal combustion engines, includes the decomposition of an amyl derivative of the metal by heat.

(360) U. S. 1,812,399 (1931). W. Gaus (I. G. Farbenindustrie A. G.), *Production of Metal Carbonyls.* Fe-carbonyl is produced by whirling the powdered metal mixed with a liquid such as paraffin oil, inert against the metal but capable of dissolving CO, in a chamber filled with CO.

(361) U. S. 1,816,122 (1931). A. Mittasch, and C. Müller, (I. G. Farbenindustrie, A. G.), *Manufacture of Iron Carbonyl.* Improvement on the production of Fe-carbonyl from action of CO on finely divided Fe.

(362) U. S. 1,825,241 (1931). A. Mittasch and L. Schlecht (I. G. Farbenindustrie, A. G.), *Metals from Carbonyls.* Method of production of metals by thermal decomposition of their carbonyls provides for freeing the CO (produced simultanuously with the metal) from CO_2, and then allowing it to act on further amounts of metal, to produce metal carbonyls.

(363) U. S. 1,836,732 (1931). L. Schlecht, and W. Schubardt (I. G. Farbenindustrie A. G.), *Decomposition of Metal Carbonyl.* Production of finely divided

metals by thermal decomposition of metal carbonyls in a hot free space of a heated vessel is disclosed.

(364) Brit. 364,781 (1932). I. G. Farbenindustrie A. G., *Metals From Carbonyls.* Decomposing carbonyls in contact with moving heated surfaces is claimed.

(365) Brit. 367,996 (1932). I. G. Farbenindustrie A. G., *Metals from Metal Carbonyls.* Preparation of metal powder such as Co, Mo, W, Cr powder from metal carbonyls consists in causing the metal carbonyls to fall in a comminuted state through a space heated to the temperature necessary for decomposition.

(366) Brit. 370,894 (1932). I. G. Farbenindustrie A. G. and M. Naumann, *Molybdenum and Tungsten Carbonyls. Cf:* U. S. 1,921,536 (No. 380).

(367) French 732,907 (1932). I. G. Farbenindustrie A. G., *Metal Carbonyls.* The production of metal carbonyls consists of continuously introducing the metallic material into, and continuously withdrawing the residue from, the reaction chamber.

(368) German 544,283 (1932). I. G. Farbenindustrie A. G. and W. Schubardt, *Metal Powders.* Pulverulent or spongy metal obtained by decomposition of carbonyl is ground preferably in inert or reducing atmosphere to increase its apparent density.

(369) German 545,710 (1932). I. G. Farbenindustrie A. G., W. Haag, M. Naumann, and L. Schlecht, *Metals from Carbonyls.* Method of producing metals comprises thermal decomposition of fine powdered carbonyls falling through space heated to decomposition temperature.

(370) German 546,353 (1932). I. G. Farbenindustrie A. G., L. Schlecht, and W. Schubardt, *Metals From Carbonyls.* The carbonyls are decomposed in a heated chamber while subjected to a whirling motion.

(371) German 562,179 (1932). I. G. Farbenindustrie A. G., M. Naumann, and L. Schlecht, *Counterflow System for Making Metal Carbonyls.* The reaction takes place in a tubular furnace filled with the metallic material, while CO is flowing upward through the furnace.

(372) U. S. 1,841,973 (1932). M. Naumann (I. G. Farbenindustrie A. G.), *Metal Carbonyls.* The action of CO on Fe takes place under pressure of 200 atm.; the carbonyl in liquid state is withdrawn from the reaction chamber, and the pressure released in two stages.

(373) U. S. 1,852,541 (1932). L. Schlecht, and E. Keunecke (I. G. Farbenindustrie A. G.), *Production of Metal Carbonyls.* A material containing a carbonyl forming metal in a form capable of conversion into a higher stage of oxidation is subjected first to an oxidation and then to a reduction treatment and then to the action of CO.

(374) U. S. 1,857,879 (1932). W. Schubardt (I. G. Farbenindustrie A. G.), *Metal Powder.* Heavy metal powders are produced by thermal decomposition of the carbonyl, and comminuting them mechanically in a ball mill.

(375) U. S. 1,858,220 (1932). L. Schlecht, E. Keunecke and W. Schubardt (I. G. Farbenindustrie A. G.), *Metal Carbonyls.* Method of production comprises mixing a material containing a carbonyl-forming metal with substances preventing sintering under subsequent conditions of reduction, and reducing the mixture below the melting point of the metal to retain it in the unsintered condition, and then treating it with CO.

(376) U. S. 1,864,673 (1932). F. Duftschmid and L. Schlecht (I. G. Farbenindustrie A. G.), *Production of Pure Metals.* Process provides for the removal from metal powders those impurities which form volatile compounds with O.

(377) U. S. 1,868,044 (1932). L. Brandt (Vereinigte Stahlwerke A. G.), *Production of Iron Carbonyl.* Production of $Fe(CO)_5$ is claimed, wherein metallic Fe is mixed with finely divided Cu to increase the yield.

(378) Brit. 393,684 (1933). I. G. Farbenindustrie A. G., *Metal Carbonyls. Cf:* French 732,907 (No. 367).

(379) U. S. 1,901,656 (1933). O. Kramer (I. G. Farbenindustrie A. G.), *Stable Suspension.* A stable suspension of materials capable of forming metal carbonyls is claimed, in which the metal in suspension may be Ni-powder.

(380) U. S. 1,921,536 (1933). M. Naumann (I. G. Farbenindustrie A. G.), *Production of Molybdenum and Tungsten Carbonyls.* In the production of Mo- and W-carbonyls suitable for thermal decomposition into powder, sponge or compact metal, the action of CO on Mo or W takes place at 210° C. (415° F.).

(381) U. S. 1,941,111 (1933). L. Schlecht, and M. Naumann (I. G. Farbenindustrie A. G.), *Production of Metal Carbonyls.* Metal carbonyls are produced by passing CO upward in a pressure vessel filled with a suspension of the metal in the carbonyl.

(382) French 767,519 (1934). I. G. Farbenindustrie A. G., *Alloys.* Pulverulent alloys are produced by decomposition of at least two metal carbonyls, coating the particles with C or the like, and sintering in non-oxidizing atmosphere.

(383) U. S. 1,944,849 (1934). L. Schlecht, and M. Naumann (I. G. Farbenindustrie A. G.), *Production of Metal Carbonyls.* Ni and other metal carbonyls are produced by using granular and powdered reaction material together.

(384) U. S. 1,975,076 (1934). O. G. Bennet (Catalyst Research Corp.), *Metal Carbonyls.* In production of metallic carbonyls, carbonyl-forming metals are converted into oxide-free metal powder by amalgamation of the metal with Hg in vacuum, then distilling the Hg from the amalgam.

(385) Brit. 423,823 (1935). I. G. Farbenindustrie A. G., *Pulverulent Alloys.* Process of production pulverulent metal alloys comprises thermally decomposing a mixture of metal carbonyls, treating the particles with a substance hindering their fritting together, and heating the powder in an inert atmosphere at temperatures high enough to effect alloying.

(386) Brit. 423,907 (1935). Catalyst Research Corporation, *Production of Metal Carbonyls. Cf:* U. S. 1,975,076 (No. 384).

(387) German 615,524 (1935). I. G. Farbenindustrie A. G., W. Haag, and L. Schlecht, *Decomposition of Carbonyls.* Method comprises producing metals by thermal decomposition of metal carbonyls on heated surfaces, and stripping off constantly the metals from the surfaces.

(388) U. S. 2,004,534 (1935). C. Müller, L. Schlecht, and E. Keunecke (I. G. Farbenindustrie A. G.), *Separation of Metals.* Base metals capable of forming carbonyls are separated from a material containing at least two such metals in a form capable of reacting with CO.

(389) German 625,049 (1936). Deutsche Gold- & Silberscheideanstalt and O. Ehrhart, *Method of Making Comminuted Precious Metals.* Precious metal flakes are made by spreading thin metal suspensions on sheet metal, then separating them by thermally decomposing and depositing the metal flakes as films and separating them from sheet metal by moistening them with acids.

(390) U. S. 2,041,493 (1936). L. Schlecht, and A. Heinzel (I. G. Farbenindustrie A. G.), *Pulverulent Alloy.* Method of producing pulverulent alloys of metals capable of forming metal carbonyls comprises thermal decomposition of a mixture of carbonyls.

(391) Canadian 363,831 (1937). International Nickel Co., C. F. R. Harrison and A. E. Wallis, *Nickel Carbonyl. Cf:* U. S. 2,070,079 (No. 394).

(392) French 809,545 (1937). I. G. Farbenindustrie A. G., L. Schlecht and G. Hamprecht, *Process of Production of Metal Carbonyls Especially Free From Sulfur. Cf:* German 654,558 (No. 393).

(393) German 654,558 (1937). I. G. Farbenindustrie A. G., L. Schlecht, and G. Hamprecht, *Pure Metal Carbonyls.* The metal carbonyls, produced by the reaction of CO with Ni containing materials, are purified by contacting them with material which absorbs S.

(394) U. S. 2,070,079 (1937). C. F. R. Harrison and A. E. Wallis (International Nickel Co.), *Nickel Carbonyl.* Process comprises pulverizing a Ni-matte to powder, moistening it with a solution of H_2SO_4, forming the powder into briquettes, arranging the briquettes in a mass free from the powdered matte, and passing through the mass CO under pressure.

(395) U. S. S. R. 51,598 (1937). V. D. Romanov, *Powdered Metals From Carbonyls.* The size of the metal particle obtained is regulated by admitting

the carbonyls at various heights into the reaction chamber which contains hot inert gases.

(396) U. S. 2,105,037 (1938). C. F. R. Harrison and A. E. Wallis (International Nickel Co.), *Nickel Carbonyl.* An unfused mixture of Ni matte containing finely divided particles of Fe or Cu is subjected to the action of CO under pressure to form Cu_2S or FeS and facilitate separation of Ni from the residue. After calcining to remove S, the residue is used in the first step of the process to effect concentration of precious metals in a Ni matte.

(397) U. S. S. R. 58,721 (1940). V. D. Romanov, *Thermal Decomposition of Metal Carbonyls.* The decomposition takes place in an electric or magnetic field and metal mixtures, metal carbides or nitrides can be produced.

(398) U. S. 2,242,115 (1941). A. Danciger, *Manufacture of Metal Carbonyls.* Metal carbonyls are manufactured by charging a selected metal in finely divided condition into the contact tower in form of a spray.

(399) U. S. 2,267,099 (1941). W. Hellriegel (I. G. Farbenindustrie A. G.), *Molybdenum Carbonyl.* Production of Mo-carbonyl comprises heating a mixture of a halide of Mo and metallic Mo, transforming this composition by reaction with hydroxides, carbonates and sulfides, and heating the resulting composition with CO.

(400) U. S. 2,378,053 (1945). A. E. Wallis and S. C. Townshend (International Nickel Co.), *Production of Iron Carbonyl.* Reducible ferrous material is immersed in $NiSO_4$ solution, reduced at 500° C. (930° F.), and subjected to action of CO at pressures not greater than 200 atm.

(401) U. S. 2,387,970 (1945). P. Alexander, *Thermal Deposition of Metals in a Vacuum.* A process of depositing by thermal evaporation in a vacuum on a support a bright film of metal selected from the group of Au, Ni, Co, Fe, Cu, Al, Cr, Ag, provides for continuously maintaining liquid a mixture of a metal of the Pt group and a small percentage of metal to be evaporated, and exposing the support to the vapor of the mixture.

(402) U. S. 2,473,993 (1949). W. F. Gresham and J. V. E. Hardy (E. I. Du Pont de Nemours & Co.), *Synthesis of Metal Carbonyls.* Ni-carbonyl in a propionic acid solution is obtained by reacting Ni propionate with H and CO at 200° C. (390° F.) and 200 atm. for 30 min.

C. Chemical Processes

i. Precipitation, Replacement and Dissolution

(403) U. S. 684,578 (1901). C. W. Merrill, *Precipitant for Recovering Metals.* Precipitant of Zn, ground to great fineness by addition of grit such as silica or emery, is used in the recovery of Cu or Ni.

(404) U. S. 778,547 (1904). L. E. Porter, *Method of Precipitating Metals from Cyanide Solution.* Metallic Cu is thrown down as red Cu from Cu-cyanide solution subjected to action of Zn-dust and HNO_3.

(405) U. S. 790,429 (1905). A. Gutensohn, *Process of Recovering Metals.* Finely divided Ni, Cu, etc., are obtained from acid solution by admixture of second solution containing alkali and resin; resin is distilled from mass of resin and metal formed.

(406) Brit. 25,846/1906 (1907). H. Kuzel, *Production of Colloidal Elements.* The comminuted elements, especially metals, are under moderate heating and good agitation alternately treated first with an acid solution and then with a basic or neutral solution, and washed after each treatment; these alternate treatments being repeated until the elements have completely gone into colloidal solution.

(407) French 371,799 (1907). H. Kuzel, *Production of Colloidal Elements.* *Cf:* Br. 25,864 (No. 406).

(408) German 186,980 (1907). H. Kuzel, *Peptisation of Colloids of Tungsten or Molybdenum.* The colloidal products of coagulation are treated with small quantities of organic or inorganic bases or with their carbonates.

(409) U. S. 860,661 (1907). W. Hendryx, *Method of Depositing and Recovering Metals.* A stream of Au- or Cu-bearing solution is passed through agitated beds of granulated Zn or Fe, the metal precipitated being carried off by the stream.

(410) U. S. 871,599 (1907). H. Kuzel, *Process for Converting Elements Into Colloidal State.* First comminuting elements, then treating under heat and agitation alternately with acid solution and non-acid solution and between treatments washing with pure liquid organic compound.

(411) U. S. 875,381 (1907). G. M. Rice, *Process of Treating Complex Ores.* Finely divided Fe is used to combine with S and reduce Zn content in treating sulfide ores to remove Zn.

(412) German 197,379 (1908). H. Kuzel, *Producing Metals in the Colloidal State.* Producing metals such as W, Mo, U, Th, Zr in the colloidal state by agitating metal powders alternately with diluted acid and alkaline solutions until the metals go completely into colloidal solution in distilled water.

(413) U. S. 886,866 (1908). D. Robertson, *Process for Extracting Metals.* Au, Ag and Cu are precipitated from solution obtained by mixing ore and aqua regia, on Fe scrap from which Au values may be scaled off.

(414) U. S. 899,875 (1908). H. Kuzel, *Process of Peptizating Colloidal Elements.* Coagulated colloids of refractory elements are treated with a solution of alkaline reaction.

(415) U. S. 900,453 (1908). A. I. Wadhams (International Nickel Co.), *Art of Separating Metals from Matte.* In process of separating constituent metals from speiss containing Co, Ni, Ag, and Fe, Ag is cemented on Cu shot.

(416) U. S. 912,246 (1909). H. Kuzel, *Manufacture of Alloys.* Method comprises adding to a colloidal suspension of metals a solution of crystalloidal compound and a precipitant, separating the deposit, molding it into desired shape, and heating the product to reconvert the structure into the crystalloidal state.

(417) U. S. 968,651; 968,652 (1910). E. Greenawalt, *Process of Extracting Metals for Ores.* Cu, Au and Ag are separated from ore by precipitating Au and Ag with electrolytic powdered Cu and casting this as anodes, depositing Cu and recovering Au and Ag from anode slimes.

(418) U. S. 1,063,567 (1913). C. W. Merrill, *Process for Precipitating Materials from Solution.* Reducing conditions (exclusion of oxidizing gases) are maintained throughout precipitation of metal from solution by agitation with Zn powder.

(419) U. S. 1,075,093 (1913). A. David, *Cyclic Process of Extracting Methods from Cupriferous Materials.* In a cyclic extraction process, Cu is precipitated by powdered electrolytic Fe, and the solution is then re-electrolyzed producing fresh precipitant.

(420) U. S. 1,123,778 (1915). L. D. Mills (Merrill Metallurgical Co., *Precipitating of Metals from Solutions.* Process for precipitating precious metals utilizes a granular Zn, Al, etc. precipitant at surface of a filter medium through which pregnant solution is withdrawn.

(421) U. S. 1,156,383 (1915). R. Towne, and C. Robinson (Metallurgical Engineering Process Co.), *Process of Precipitating and Separating Precious Metals from Solution.* Au or Ag is separated from a cyanide solution by Zn economically used in a powdered form.

(422) U. S. 1,160,849 (1915). H. R. Conklin, *Precipitation.* The metallic precipitant is eliminated from the precipitate by moving the precipitant in form of balls, rather than shavings, through the pregnant solution.

(423) Canadian 185,437 (1918). B. Hamilton, *Metal Extraction.* Consists of mixing pulverized W ore with water and carbonate of alkali metal to form a pulp, and to produce a soluble compound, and then heating the pulp to complete reaction, and recovering the metal by precipitation.

(424) U. S. 1,333,985 (1920). F. Laist, *Apparatus for Precipitating Copper.* Method and apparatus for precipitating Cu from hot $CuSO_4$ solutions with SO_2 are claimed.

(425) U. S. 1,395,811 (1921). H. W. Gepp (Electrolytic Zinc Co.), *Treatment of Zinc Bearing Ores.* In electrolytic process for producing Zn to make lithopone, Zn dust is used to precipitate Co.

(426) German 352,783 (1922). H. Bardt, *Precipitation of Metals from Their Salt Solutions.* Solutions of Au or Ag with 5% Cu and 3-5% H_2SO_4 are mixed with sawdust and heated in a closed vessel to 120-150° C. (250-300° F.).

(427) U. S. 1,492,282 (1924). F. M. Becket (Union Carbide & Carbon Research Laboratories), *Process for Recovering Values from Metal Bearing Solutions.* Precious metals are precipitated from cyanide solution by an alloy of Si and an activating metal such as Ca.

(428) U. S. 1,492,283 (1924). F. M. Becket (Union Carbide & Carbon Research Laboratories), *Process of Recovering Values from Metal Bearing Solutions.* Heavy metals are precipitated from cyanide solution by an alloy of Si and an activating metal such as Ca.

(429) U. S. 1,503,229 (1924). L. F. Clark, *Process of Treating Solution of Metals.* In recovering metallic Cu, metallic impurities are first precipitated from solution as salts by increased temperature and pressure.

(430) U. S. 1,686,391 (1928). C. Müller, L. Schlecht, and W. Schubardt (I. G. Farbenindustrie A. G.), *Process for Precipitating Heavy Metals.* Spongy gray silver precipitate and pale red metallic Cu powder are successively precipitated by water-gas from ammoniacal solution.

(431) U. S. 1,739,772 (1929). U. C. Tainton, *Precipitation of Metals.* Au or Ag is precipitated from cyanide solution with Zn, Pb or Cu as metal higher in electrochemical scale. From mixed deposit of granular form, Zn is dissolved out to leave Ag.

(432) U. S. 1,792,262 (1929). W. C. Wilson, *Method of Preparing Finely Divided Metals.* Finely divided metals and alloys or colloidal suspensions thereof are formed by precipitating Cu from acid solution by powdered Zn. A finer precipitant produces a finer precipitate.

(433) U. S. 1,829,635 (1931). W. P. Davey (General Electric Co.), *Method of Making Alloys.* Formation of alloy powders, such as brass or Ni-Fe, is accomplished by precipitation of their oxides or hydroxides from aqueous solutions of their compounds such as nitrates.

(434) French 736,266 (1932). S. A. Trefileries et Laminoirs du Havre. *Precipitation of Metals.* Precipitation of a metal is caused by the addition of another metal, the two being far apart in the electromotive series (*e. g.*, Fe or Ni precipitated by Al), whereby the fineness of the added metal regulates the grain size of the precipitated metal.

(435) Brit. 403,469 (1933). S. A. Tréfileries et Laminoirs du Havre. *Precipitating Metals.* Production of fine Cu, Ni or Fe powders from their saline solutions comprises treating them with Al powder and by adding to the solution chlorides which destroy layers of oxide on the Al.

(436) U. S. 1,963,893 (1934). E. Drouilly, *Production of Metals such as Copper, Nickel and Iron in a Finely Divided State.* Process comprises precipitation of first Cu and then Ni or Fe by reacting a solution of the sulfate with powdered Al in the presence of NaCl.

(437) German 630,184 (1936). I. G. Farbenindustrie A. G., *Method of Producing Finely Powdered Alkali Metals.* Method of producing finely powdered alkali metals consists of dissolving the alkali metal in liquid NH_3 and injecting the solution into an inert liquid in which the alkali metal is separated by very quickly evaporating the NH_3.

(438) German 648,543 (1937). S. A. Tréfileries et Laminoirs du Havre. *Method for Separating Metals.* Method for separating metals from the solutions of their salts comprises adding Al and an acid for the solution of the oxides on the Al particles, whose grain size determines the grain size of the precipitated metal particles.

(439) U. S. 2,070,134 (1937). H. E. Keyes, *Preparation of Iron as a Precipitant.* Fe for precipitating Cu is formed by pouring molten Fe into water forming hollow spheroids which serve to precipitate Cu in flake form rather than in granular powder.

(440) U. S. 2,100,865 (1937). L. D. Mills, T. B. Crowe, and J. C. Haun (Merrill Co.), *Cyanide Process For Precipitation of Precious Metals.* Zn particles, used to precipitate Au or Ag from cyanide solutions, are made more effective by contacting with Pb salt.

(441) Brit. 495,259 (1938). G. N. Wirsebom, *Improvement in or Relating to the Consolidation of Precipitated Metals.* Pb or Cd sponge is obtained by precipitation of the metals from solutions.

(442) U. S. 2,177,412 (1939). N. D. Scott, and J. F. Walker (E. I. Du Pont de Nemours & Co.), *Process for Reducing Metal Compounds.* Metal powders of very fine particle size are produced, *e. g.*, by reducing a Ni-halide by reacting with a solution of Na, addition of a compound of naphthalene, filtering, and washing the precipitate with organic solvent and water.

(443) U. S. 2,254,976 (1941). A. R. Powell (Johnson, Matthey & Co., Ltd.), *Metals and Alloys in Powdered Form.* Production of Cu, Ag, Au, Fe, Ni or Co is accomplished by chemical agitation of their compounds by a conversion operation at a temperature below their melting points, which consists in forming by co-precipitation from the solution of salts a mixture of a water-insoluble compound of the metal and a distribution agent.

(444) Brit. 582,921 (1946). Powderloys Ltd., *Separation and Recovery of Carbides from Sintered Hard Metals.* Carbide particles are recovered from hard metal scrap by alloying them with Zn, thus increasing the solubility of the binding metal in acid.

(445) Brit. 590,552 (1947). P. G. Brundell, and S. H. Tjernstroem, *Metals, Oxides, Shales from Bituminous Shales.* Bituminous shales are treated for recovery of V, Mo, W, Ti, as well as Fe, in a three stage process.

(446) U. S. 2,424,866 (1947). M. J. Udy, *Process for Treatment of Matte to Recover Metallic Salts.* Method of treating matte containing sulfides of iron and nickel to produce separate Fe-bearing and Ni-bearing products comprises digesting the matte with an aqueous solution of H_2SO_4 to produce $FeSO_4$.

(447) Ital. 422,565 (1948). E. Capriati, *Cyclic Process for Recovery of Copper and Zinc.* Zn-Cu alloys are dissolved by H_2SO_4 in presence of O_2. Zn scrap or powder is added to produce Cu by cementation, and the liquor is condensed and $ZnSO_4$ crystallized out.

(448) Brit. 626,882 (1949). The Permutit Co. Ltd., *Recovery of Metal Compounds from Solutions.* Chromates, molybdates, tungstates are passed over the chloride or the sulfate of ion-exchange resins and recovered by means of NaCl or Na_2SO_4 reaction.

(449) U. S. 2,476,420 (1949). R. W. Krebs, *Method and Recovery of Precious Metals.* The major portion of cyanide soluble precious metal values is recovered in powder form by adding a granular non-friable adsorption of precious metal values present.

(450) U. S. 2,478,652 (1949). R. E. Byler and R. C. Dunn (Merrill Co.), *Process For The Recovery of Precious Metal Values.* In this process for recovery of Au and Ag from ores, the metals are dissolved in alkali cyanide solutions and then sorbed on finely divided char.

(451) U. S. 2,479,930 (1949). E. C. Herkenhoff, and N. Hedley (American Cyanamid Co.), *Recovery of Precious Metal Values By Cyanidation.* The invention uses activated C for the cyanidation process, in which magnetic materials, such as finely divided Fe, ferroalloys, magnetite, etc., have been incorporated so that C-particles are magnetic enough to permit recovery on ordinary magnetic separators.

ii. Gaseous Reduction

(452) U. S. 116,903 (1871). J. D. Whelpey, and J. J. Storer, *Improvement in Treatment of Ores by Means of Fuels, Chemicals and Fluxes.* The process consists of treating ores with fluxes and chemical reagents by combining the ore and flux in fine powder and floating them into the surface by means of an air blast or steam jet.

(453) U. S. 156,243 (1874). N. W. Wheeler, *Improvement in Reducing Ores.* Metals are produced from ores by showering of granulated ore downward through a double atmosphere over a column of reducing gas.

(454) U. S. 791,928 (1905). M. Moore, *Process of Treating Ferruginous Ore.* Finely divided ore at red heat is subjected to action of a reducing gas and passed beneath molten bath.

(455) U. S. 1,003,627 (1911). W. Mathesius, *Process for Reduction of Metal Oxydes.* Preheated metallic oxide ores and reducing gases are mixed.

(456) U. S. 1,221,873 (1917). I. Ladoff (W. D. Edmonds), *Process of Producing Alloys.* A mixture of oxides of constituent metals and a compound whose reducing temperature is lower than that of the oxides is heated in reducing atmosphere, and results in alloy powders.

(457) French 485,553 (1918). M. J. Insull, *Electrical Reduction Furnace.* Furnace for the reduction of oxides, *e.g.*, WO_3, with an atmosphere of H_2 streaming very quickly through the silica tube of the furnace, has a mounting of Ni.

(458) U. S. 1,283,286 (1918). C. A. Pfanstiehl, *Process for Reducing Metal Oxides.* Metallic oxides, such as W or Mo, are heated in an atmosphere of rapidly moving H_2 at uniform temperature.

(459) French 679,699 (1930). I. G. Farbenindustrie A. G., *Manufacture of Finely Divided Metals.* Reducing vapors of compounds includes reduction of a compound (*e.g.* $FeCl_3$) by H_2 at 1000° C. (1830° F.).

(460) U. S. 1,785,427; 1,785,428 (1930). W. H. Smith, *Apparatus and Process of Reducing Ore and Converting Hydrocarbons.* Furnace enables reduction of ores at relatively low temperature without melting.

(461) U. S. 1,841,625; 1,841,626 (1932). A. Musso (W. P. Deppe), *Retort Furnace.* Reduction furnace of special retort construction for the continuous treatment of ores is claimed.

(462) U. S. 1,851,376 (1932). W. H. Smith (General Reduction Corp.), *Treating and Recovery of Gangue from Metals.* Consists of mixing comparatively cold and finely divided reduced metal with a flux to form water-soluble compounds with the gangue and then reducing the compounds separately from the metal.

(463) U. S. 1,863,507 (1932). G. T. Southgate, *Agglomerating and Reducing Ores.* Process consists of agglomerating and reducing ores which comprises comingling comminuted ore and hydrocarbon, subjecting them to heat and to pressure to drive off the hydrocarbon gases.

(464) U. S. 1,902,089; 1,902,090 (1933). A. Musso (W. P. Deppe), *Process of Mineral Production and Metal Extraction.* Process comprises low-temperature reduction of minerals of metals under conditions of decreased pressure or partial vacuum, and the subsequent treatment of the metal product in a continuous process.

(465) German 595,069 (1934). O. Wyss, *Production of Semi-Pyrophoric Metals.* Semi-pyrophoric metals, having an ignition temperature between 100 and 350° C. (210 and 660° F.), are reduced from the metal salts with H_2, which streams through the reduction vessel until the powder is cooled.

(466) Swiss 179,458 (1935). O. Wyss, *Production of Semi-Pyrophoric Metals. Cf.:* German 595,069 (No. 465).

(467) U. S. 1,988,541 (1935). N. C. Christensen, *Apparatus for Treating Finely Divided Solids, such as Sponge Iron.* Various details for producing the gas circulation for the production of the material are given.

(468) U. S. S. R. 44,938 (1935). S. B. Belynskii, *Gaseous Reduction Process.* Apparatus for a direct and continuous reduction of powdered ores in a current of gas is claimed.

(469) U. S. 2,122,053 (1938). H. Berkhardt, *Metallic Articles.* Hammer scale is mixed with oils or fats non-volatile at the temperatures at which the metal compound can be reduced and sintered, and a metal hydroxide, such as $Fe(OH)_3$, adapted to absorb the oil; the mixture is heated in a reducing atmosphere.

(470) Brit. 512,502 (1939). I. G. Farbenindustrie A. G., *Reduction of Difficultly Reducible Oxides.* Method comprises subjecting such oxides as Cr_2O_3 to a heat treatment with C and H_2 and working under reduced pressure (vacuum).

(471) Italian 371,055 (1939). I. G. Farbenindustrie A. G., *Reduction of Difficulty Reducible Oxides. Cf.:* Brit. 512,502 (No. 470).

(472) U. S. 2,184,300 (1939). F. Hodson, and P. A. Hirsch, *Method of Beneficiating or Reducing Ores to Metal.* It comprises reducing the ore to metal by introducing pulverulent ore into a violently turbulent and upwardly flowing column of reducing gases, maintaining the temperature of the gases below the fusing point of metal and then separating the metal from the gases.

(473) French 853,112 (1940). Associacion des Ouvriers en Instruments de Precision, *Production of Iron or Ferromagnetic Powders.* Consists of two operations; first the crude metal is oxidized, and then the grains are reduced to produce a pure powder.

(474) Swedish 101,410 (1940). I. G. Farbenindustrie A. G., *Reduction of Difficultly Reducible Oxides. Cf.:* Brit. 512,502 (No. 470).

(475) German 710,984 (1941). Siemens & Halske A. G., *Bulk Core Powder.* Oxides or other compounds of component metals are treated in a special furnace at 700-1300° C. (1290-2370° F.) with illuminating gas in such a manner that C is deposited. Thereupon or after preliminary purification, the powdered metals are reduced in a reduction furnace.

(476) U. S. 2,236,441 (1941). C. Hardy (Hardy Metallurgical Co.), *Metallurgical Apparatus.* Reduction furnace for metal ore has a shaking table provided with a corrugated perforated deck, for the separation of particles of different specific gravity.

(477) U. S. 2,236,474 (1941). C. Hardy (Hardy Metallurgical Co.), *Reduction of Metal Compound without Fusion.* Reducing finely divided metal oxide by means of hot H_2 comprises passing the reducing gas through a bed of particles while on a deck with an oscillating motion.

(478) U. S. 2,243,110 (1941). I. D. Madaras, *Method for Reducing Ores.* Reducing gas is circulated through successive chambers containing the ore.

(479) U. S. 2,265,812 (1941). T. Nagel, *Method of Reducing Metallic Oxides to Metal Without Melting.* Reducing metallic oxide ore to metal is done by crushing under flow of heated reducing gas.

(480) U. S. 2,267,041 (1941). R. L. Patterson (Hardy Metallurgical Co.), *Metallurgical Furnace.* Furnace is suitable for reducing, carburizing or nitriding powdered materials.

(481) Brit. 546,490 (1942). C. Hardy, *Apparatus for Producing Finely Divided Metals.* Powdered metals are produced directly from finely divided metallic oxides, without fusion by passing hot H_2 over oxide particles. Powder so produced is substantially free of oxide films.

(482) Brit. 551,249 (1943). Metals Disintegrating Co. and W. M. Triggs, *Process and Apparatus for Reduction of Copper Oxides.* Cu powder of constant physical characteristics is produced economically in mass production by reducing Cu-oxides in a continuous process in a horizontal tunnel furnace, which permits preheating, heating to 450-550° C. (840-1020° F.), and cooling in a stream of non-oxidizing gases flowing in direction of the metal, and a reducing gas passing in counterflow. Mixtures of 60-90% Cu_2O with balance CuO and small amount of Cu as catalyst are used as starting oxide.

(483) U. S. 2,307,064 (1943). R. L. Patterson (Powder Metals & Alloys Inc.), *Ore Dressing.* Metal oxides are treated to remove gangue before reducing them to form high grade metal powder.

(484) U. S. 2,307,997 (1943). G. D. Dill, *Process of Reducing Metallic Oxides.* Reducing crushed metallic oxide is accomplished by contacting it with gasified hydrocarbon or super-heated vaporized hydrocarbon oil.

(485) U. S. 2,316,664 (1943). H. A. Brassert, and J. C. Hartley, (Minerals & Metals Corp.), *Apparatus for Controlling Reduction of Powdered Ores.* The hearth is inclined for the cross-flow of fluid-permeated finely divided solids, and a series of dams provides the desired depths of solid flow, while the discharge end is downward inclined to the forward portion of the hearth.

(486) U. S. 2,326,163; 2,334,434 (1943). R. L. Patterson (Powder Metals & Alloys Inc.), *Heat Treatment Furnace for Reduction of Finely Divided Metal Compounds.* Finely divided metal compound, such as Fe oxide, is treated with a gaseous reducing agent, such as H_2, to produce a powder of the metal and a gaseous reaction product. Process involves upwards movement of charge and downwards counterstream flow of reducing gas, discharge of metal powder on top and gaseous reaction product, heavier than gaseous reducing agent, on bottom.

(487) U. S. 2,331,419 (1943). R. L. Patterson (Powder Metals & Alloys Inc.), *Furnace for Reduction of Metal Oxides.* Furnace is adapted to treatment of finely divided metal oxides and the like with gaseous treating agents.

(488) U. S. 2,343,780 (1944). W. K. Lewis (Standard Oil Development Co.), *Reaction between Solid and Gases.* Metal powders, such as Fe or Ni, are produced by reduction of powdered ores with natural gas rich in H.

(489) U. S. 2,351,765 (1944). B. A. Jeffery, *Reducing Ores Forming Sponge Metals.* Process comprises reducing ores with reducing gases on pellets formed of ore and vaporizable liquid, producing porous spongy metal pellets.

(490) U. S. 2,352,418 (1944). H. G. Twiford, *Ore Reducing Apparatus.* Apparatus for use in recovering metal powders from ore is claimed.

(491) U. S. 2,367,262 (1945). H. A. Brassert (Minerals & Metals Corp.), *Process for Producing Metal Powders.* Metal powders are produced from their finely divided ores by downdrafting hot oxiding gases through them, producing temperatures for partial sintering of the material, and then downdrafting reducing gases through the material.

(492) U. S. 2,373,657 (1945). D. N. Burruss, Jr., and J. E. Drapeau, Jr. (Glidden Co.), *Metal Sponge.* Production of sponge Fe or Cu powder by maintaining a bed of divided metal oxide within a reducing zone. Charge is uniformly heated and periodically agitated and advanced toward point of ejection.

(493) U. S. 2,384,971 (1945). J. E. Silvasy, and L. Taylor, *Apparatus for Producing Metal Powder.* Apparatus for reducing metallic oxide ores to pure metallic powder consists mainly of a retort and means for mixing pulverized ore and hydrocarbon gas to cause the pulverized ore to be carried in a gaseous suspension which is introduced into the retort.

(494) U. S. 2,389,133 (1945). H. A. Brassert, and C. F. Ramseyer (H. A. Brassert & Co.), *Apparatus for Reduction of Metals.* In a perforated hearth for reduction of fine ores the gas flows through the ore bed at a sufficient velocity to obtain the desired fluid condition, without tendency toward channeling.

(495) U. S. 2,391,496 (1945). C. J. Westling (Minerals & Metals Corp.), *Metallurgical Apparatus.* Finely divided metal compounds or ores are reduced and prevented from sintering in a furnace which agitates the charge and maintains good contact between charge and reducing gas.

(496) Japan 172,473 (1946). K. Kubo, and M. Nakajima, *Metal Refining.* Pulverized metal oxides are reduced under pressure in a closed electrical furnace by compressed CO.

(497) U. S. 2,404,944 (1946). H. A. Brassert, *Apparatus for Reduction of Oxides.* An apparatus for reducing finely divided metallic ores by reducing gases is claimed.

(498) Swedish 118,801 (1947). E. H. Johansson, *Metal Powders.* Metal powders having spherical granules are made by reducing a salt of metal with a non-noble metal, with the reactants brought together in gaseous form.

(499) U. S. 2,418,394 (1947). C. O. Brown (American Ore Reduction Corp.), *Method of Reducing Ores.* High temperature combustion gases are brought in contact with the reducing material by falling through the upward flowing gases.

(500) Brit. 602,023 (1948). Metals Disintegrating Co., Inc., *Making Metal Powders.* Spherical Cu-Ni powder of controlled size is made by mixing the -5 μ oxides in moist air, screening and reducing the resulting granules.

(501) French 934,294 (1948). Comp. Générale de Telegraphie Sans Fil, *Reduction Furnace for Pulverulent Material.* A vertical helical tube with a heated zone is vibrated through elastic joints. The powder is thus reduced in continuous process without ball-milling and sifting.

(502) U. S. 2,436,157 (1948). C. J. Westling (Minerals & Metals Corp.), *Metallurgical Process.* A reducing furnace for finely divided ore has a hearth on which the thickness of the charge and the reducing gas, particularly near the point of discharge, are regulated.

(503) U. S. 2,455,092 (1948). C. F. Ramseyer and H. A. Brassert (H. A. Brassert & Co.), *Apparatus for Gaseous Reduction of Metals.* The feed means comprise a vertical duct, leading to the hearth, which is adjustable vertically, so that the incoming material enters the bed below the surface; the edge of the discharge dam may be raised and lowered, to adjust the depth of the bed.

(504) Brit. 615,580 (1949). Metals Disintegrating Co. Inc., *Manufacturing Masses of Metal Particles.* When oxide-reduced powders of particles smaller than 10 μ are to be made from similarly sized oxides, it has been found possible to prevent agglomeration by admixing to the oxides a small percentage of starch by ball-milling in a liquid.

(505) U. S. 2,470,106 (1949). V. F. Parry, *Process for Reducing Iron Ores.* High heat economies are achieved in a method for endothermic chemical reactions involving solid and gaseous materials, such as the gasification of lignite with concomitant reduction of sintered or briquetted Fe ore.

(506) U. S. 2,479,435 (1949). H. G. Vesterdal (Standard Oil Development Co.), *Process of Reducing Iron Group Metal Oxides.* The oxides and carbonates of Fe, Ni and Co are reduced to obtain reduction products useful as catalyst, the powdered solid O-compounds being suspended in a reducing gas. The improvement comprises separating solids reduced to a total O-content of not more than 5% from reduced solids of a higher O-content by means of a magnetic field while the reduced solids are suspended in the reducing gas.

(507) U. S. 2,481,217 (1949). C. E. Hemminger (Standard Oil Development Co.), *Process for a Two-Stage Gaseous Reduction of Iron Ore.* The ore, in the form of a dense, fluidized bed of powder is subjected to a normally gaseous hydrocarbon at elevated temperatures in a first reduction zone, after which partially reduced ore is withdrawn from the zone and discharged into a second reduction zone, where it is treated at elevated temperatures while in the form of a dense, fluidized bed with a gas rich in H. A product comprising the original ore in metallic state is finally recovered from the second reduction zone.

(508) U. S. 2,481,226 (1949). R. W. Krebs (Standard Oil Development Co.), *Two-Stage Reduction Process for Producing Metal Catalyst.* A heavy metal oxide of the class consisting of Fe and Co oxide is reduced at elevated temperature and atmospheric pressure to form a catalyst material. The process comprises forming the catalyst in powdered form into a fluidized mass and then subjecting it to the reduction treatment.

(509) U. S. 2,491,210 (1949). R. F. Rennie (Westinghouse Electric Corp.), *Tube Furnace for Producing Metal.* In a furnace for the reduction of MoO_3 to Mo, the charge is moved forward at constant speeds into zones of increasing temperature and in a direction opposite to that of the flow of the reducing gas. Gas may thus be introduced in its most concentrated condition and diminish in strength, not only by the steam evolved during the reduction process but also by the addition of desired amounts of steam along the length of the furnace.

iii. Hydride Reduction

(510) U. S. 2,038,402 (1936). P. P. Alexander (General Electric Co.), *Method for Reduction of Refractory Oxides.* Consists of heating the oxide and a metal containing H in close association in vacuum and at temperature high enough to liberate H.

(511) U. S. 2,043,363 (1936). P. P. Alexander (Ventures Ltd.), *Reduction of Ores by Metallic Calcium.* Reducing powdered compounds is accomplished by placing ingots of Ca into a container filled with H_2, raising the temperature, crushing the Ca into fine powder and mixing a powdered compound with Ca, expelling H_2 by establishing a vacuum, and further raising the temperature above red heat.

(512) U. S. 2,287,771 (1942). P. P. Alexander, *Powdered Alloys by Hydride Reduction.* A metal such as Ti, Zr, W, Hf, Th, Ta, U, Mo, Cr or Be is alloyed with Ti, Zr, Hf, W, Th, Ta, U, Mo, Cr, Be, C, Fe, Ni or Co; non-oxide of the first group is combined with an element of the second group plus a hydride of Ca, Ba or Se, and the mixture is heated to liberate H.

(513) U. S. 2,397,831 (1946). H. T. Bellamy, *Production of Molded Metallic Articles.* Process comprises mixing metallic particles with hydrated metal hydroxide, forming colloidal-like suspensions, which are capable of being reduced, forming the mixture to shape, and heating in a reducing atmosphere to reduce the metal hydroxide to metal.

iv. Reduction by Solids

(514) U. S. 880,799. (1908). I. T. Jones, *Method of Reducing Ores.* Finely divided ore is reduced with lump coke and separated from gangue by gravity, magnetic separation, etc.

(515) French 419,043 (1910). H. Kuzel, and E. Wedekind, *Production of Pure Metals.* Reduction of oxides of metals, such as W, Mo, Ti, V, Th, is done by mixing them with metallic Ca and heating.

(516) U. S. 1,415,516 (1922). A. Bridge, *Method and Apparatus for Reducing Refractory Metal Oxides.* Reducing the oxides of refractory, acid forming, metals such as W, Mo, Ta, Cb, is accomplished by a thermal reaction with Al, Mg, Ca, in a closed vessel with a layer of the particular oxide, to be agitated by the thermal reaction.

(517) U. S. 1,437,984 (1922). J. W. Marden, *Production of Rare Metal Powder By Aluminothermic Reduction.* Halide of metal to be formed and Al are heated to the temperature of reaction, then further heated to volatilize all salts.

(518) German 441,639; 441,640 (1927). Westinghouse Lamp Co., *Production of Refractory Metals.* It consists of mixing refractory metal oxides with halides of earth alkali metal and an alkali metal which is different from that of the halides used, and heating in inert atmosphere to separate all impurities.

(519) U. S. 1,659,209 (1928). J. W. Marden (Westinghouse Lamp Co.), *Production of Rare Metal Powder.* Oxide of rare refractory metal is heated with Mg and a fluxing agent to produce metal powder.

(520) U. S. 1,704,257 (1929). J. W. Marden, T. P. Thomas, and J. E. Conley (Westinghouse Lamp Co.), *Method of Preparing Refractory Metals.* Difficultly reducible oxides are heated to reacting temperature with an alkaline earth metal and an alkaline earth halide.

(521) U. S. 1,728,941 (1929). J. W. Marden, and M. N. Rich (Westinghouse Lamp Co.), *Production of Rare Metals.* Preparation of Ta, V and Cb powder free from H and N involves reducing an oxide-mixture of the metals with Ca and $CaCl_2$ in a sealed or evacuated container in the presence of an alkali metal at elevated temperature.

(522) U. S. 1,841,602 (1932). I. Hornsey (Granular Iron Co.), *Treatment of Iron Ores.* Mixture of Fe ore and solid carbonaceous fuel is treated in rotary kiln at high temperature.

(523) German 600,369 (1934). W. Rohn (Heraeus Vacuumschmelze A. G.), *Reduction of Oxides with Carbides.* Zr is made by causing a carbide of Zr to react with ZrO_2 in a bath of fused Zr under reduced pressure. Si, Ti, Hf, V, Ni, Cr and Mo are obtained similarly.

(524) Brit. 507,494; 507,581 (1939). H. Gallusser, *Reduction of Metal Oxides.* Comprises placing the ore and the reduction material in a closed vessel with walls which form a secondary winding of a transformer with closed Fe path, to produce an induction current.

(525) German 694,150 (1940). N. D. Scott and J. F. Walker (E.I. du Pont de Nemours & Co.), *Method of Producing Finely Comminuted Metals.* Method of obtaining finely comminuted metals such as Ni, Sn, Cu, Pb by reduction of metal compounds is based on reactions of alkaline metal compositions in the form of addition agents and suitable organic compounds with salts of non-alkaline metals, and results in particularly fine and pure metal powders.

(526) U. S. 2,261,196 (1941). S. K. Wellman, and C. H. Tower (S. K. Wellman Co.), *Process for Making Metal Powder.* It comprises carbonaceous reduction of a mixture of oxidic compounds of Pb and Fe, Co, Ni, or Mn, whereby the compounds may be reduced by means of solid C, to form a loosely sintered cake, which is then separated from the unconsumed reducing agent.

(527) Brit. 544,840 (1942). S. K. Wellman Co., *Metal Powders. Cf:* U. S. 2,261,196 (No. 526).

(528) French 873,879 (1942). L. Breda, and G. Lefebre, *Production of Hard Metal for Replacing Tungsten Carbide.* A mixture of Fe oxide, boric acid and SiO_2 is agitated by aluminothermic reaction.

(529) U. S. 2,285,487 (1942). J. E. Batie (Kelsey-Hayes Wheel Co.), *Reducing Oxides for Production of Sponge Iron.* Apparatus and method for reducing metal oxides by carbonaceous powdered material, comprises conveying powdered oxides in layers through a heated horizontal reducing furnace chamber, with layers of the carbonaceous material, separated by paper strips, placed above and below the powdered oxide layer.

(530) U. S. 2,301,663 (1942). E. Zintl and W. J. Morawietz, *Process for Preparing Metals.* Comprises reducing difficultly volatizable metal oxides at high temperatures with the aid of Si.

(531) Brit. 563,145 (1944). M. J. Udy, *Reduction of Metals and Alloys From Oxides.* Mixture of finely divided oxide of one of metals Cr, Mn, V, W, Ti, or Mo and finely divided CaO is heated to a temperature sufficiently high to effect chemical combination of the CaO and the alloy metal oxide. Product in finely divided form is mixed with solid finely divided non-carbonaceous reducing material.

(532) German 749,749 (1944). E. Zintl and W. J. Morawietz, *Preparation of Metals and Alloys by Oxide Reduction with Silicon.* Oxides of metals of scandium, Ti, V, and Cr are reduced with Si under such conditions as to give the pure metal and Si-monoxide.

(533) U. S. 2,359,578 (1944). C. Q. Payne, *Apparatus for Reduction of Ores.* Apparatus for producing metal powders by reducing ores with C consists of an electromagnet having a dual magnetic flux circuit, and an induction furnace, whose charge forms the downward moving core of the electromagnet.

(534) U. S. 2,397,993 (1946). N. J. Urquhart (Combustion Processes Co.), *Reduction of Metallic Oxide.* Reduction of metallic oxides in finely divided state is accomplished with finely divided coal.

(535) U. S. 2,448,000 (1948). F. R. Kemmer (Reynolds Metals Co.), *Manufacture of Alkaline Earth Metals.* Process consists of mixing an oxide of an alkaline earth metal with Al and a mixture of Al-nitride, Al-carbide or Al-oxide, heating the mass to 1100° C. (2000° F.) to cause reduction of the oxide to free alkaline earth metal, and distilling in vacuo.

(536) U. S. 2,462,900 (1949). J. P. Riott, *Reduction Accelerator for the Sponge Iron Rotary Kiln Process.* Method comprises the thermal reduction of a mixture of a metallic ore and a carbonaceous reducing agent. The reduction is carried out in the presence of at least one alkali metal aluminate.

v. Carburization and Decarburization

(537) French 732,958 (1932). I. G. Farbenindustrie A. G., *Production of Metals or Alloys with Inclusions of Carbon.* Method comprises heating the metal powders with C which is produced by thermic decomposition of gases or vapors of C-compounds in contact with catalysts.

(538) U. S. 1,874,641 (1932). R. L. Sessions (Molybdenum Corp.), *Method of Preparing Carbides.* Carbides of more than 2 metals, one of which does and the other one of which does not form carbide readily, are produced by bringing about a close association of their powders while chemically combined, and reducing one constituent while carbonizing the other.

(539) Austrian 144,828 (1936). Gebr. Böhler & Co., A. G., *Production of Sintered Hard Alloys.* The carburizing takes place in several steps, with intermediate fine milling between the heating runs, to inhibit the growing of the carbide grain size.

(540) Canadian 437,561 (1940). N. K. G. Tholand, *Manufacture of Powdered Metal.* Molten pig iron is atomized, ball-milled to a suitable size, and decarburized, the removal of graphitic carbon leaving a porous powder.

(541) U. S. 2,205,386 (1940). C. W. Balke, and C. C. Balke (Fansteel Metallurgical Corp.), *Production of Metals and Alloys.* Method comprises producing metals and alloys by interaction of metal oxides and metal carbides at a temperature at which the oxide volatilizes as such, and then raising the temperature to a point below the melting point of the metal being produced, to complete the decarburizing reaction.

(542) U. S. 2,216,770 (1940). J. E. Drapeau and L. G. Klinker (Glidden Co.), *Method of Making Metal Powders.* Powdered metal, coated with an organic compound, is heated to carbonize the compound.

(543) U. S. 2,237,867 (1941). C. A. Mann (General Motors Corp.), *Method of Making Sponge Iron Powder.* Consists of decarburizing steel scrap in the molten state to a C-content of less than 0.05% by disintegrating it into small particles, and oxidizing these to pure Fe oxide, followed by reducing them to sponge Fe.

(544) Belgian 447,218 (1942). I. Rennerfelt, *Shaped Objects of Iron or Its Alloys Without Fusion.* Fused metal is rapidly cooled in water or steam, and the granular material thus produced is decarburized, powdered in a colloidal mill, and re-carburized by heating in carbonaceous gas.

(545) U. S. 2,329,862 (1943). R. H. Terry, and D. J. Henry (General Motors Co.), *Apparatus for Treating Metal Powders.* Process and apparatus are shown for decarburizing and/or deoxidizing metal powder containing C or metal oxides by heat treatment.

(546) U. S. 2,362,772 (1944). I. Rennerfelt, *Powder Metallurgical Methods.* Method of producing fine ferrous metal powder comprises preparing in subdivided form a high C-content ferrous metal, decarburizing, mechanically disintegrating the soft material to produce a fine powder, and thereafter carburizing.

(547) Brit. 573,564 (1945). W. D. Jones, and A. G. E. Robiette, *Decarburization of Carbide Powders.* A cast Fe powder containing carbides of Fe, B, Co, Mn, Ni, Ta, Ti, W is subjected at 750-1100° C. (1380-2010° F.) to a decarburizing but non-oxidizing atmosphere containing H, not more than 8% water vapor, 2.5-9% CO_2, 5-30% CO. For example, a powder containing 3% C, 1% Mn, 0.6% Si, 0.1% P, and 0.06% S is heated to 900° C. (1650° F.) in an atmosphere consisting of 11% H, 9% CO, 6% CO_2, 1% H_2O, balance N, and yields a Fe powder of 0.15% C.

vi. Oxidation

(548) U. S. 480,956 (1892). B. Moebius, *Process of Treating Amalgam.* Bullion in powder form containing Ag and Au is produced from an amalgam, which has been comminuted, and the base metals are oxidized and leached therefrom.

(549) Brit. 322,082 (1929). I. G. Farbenindustrie A. G., *Purifying Metals such as Iron.* Impurities which form volatile oxides are oxidized by adding just sufficient oxygen.

(550) German 523,393 (1931). Metallgesellschaft A. G., *Dwight-Lloyd Apparatus for Sintering.* Premature sintering in roasting of ore is prevented by control of the quantity of roasting charge and the heat generated in it; this is accomplished by keeping the width of the furnace conveyor belt very small.

(551) Brit. 373,784 (1932). Hartstoff-Metall A. G., *Oxidizing Treatment of Aluminum Powder.* Al powder is subjected to treatment in an atmosphere consisting of a mixture of a gas inert to the particles and a small portion of an oxidizing gas.

(552) U. S. 2,050,319 (1936). C. W. Hanson (American Smelting & Refining Co.), *Treating Metalliferous Composition of Copper, Tin and Lead.* In freeing scrap-radiator alloy of Cu from residue of Sn and Pb, granulated and powdered forms of the alloy are roasted to oxidize the Cu so it may be removed by leaching.

(553) Canadian 363,511 (1937). E. Kramer, *Metal Powders.* Treating powder with gas containing a small percentage of O to cause partial oxidation is claimed.

(554) U. S. 2,123,593 (1938). M. Vogel-Jorgensen (F. L. Smidth & Co.), *Apparatus and Operation For Treating Solids With Oxidizing Gases As in Sintering Ores.* A rotary drum has a gas-permeable peripheral surface, and radial chambers which are closed at their ends, except for an air suction tube.

(555) German 682,724 (1939). T. B. Gyles, and S. Robson (National Smelting Ltd.), *Sintering Ores.* Method for sintering of Zn ores which contain Pb or Cd comprises sintering the ores under oxidizing conditions in layers, separated from another by non-sintering layers on a traveling grate.

(556) U. S. 2,264,338 (1941). F. N. Hillis, and W. Seguine, (Glidden Co.), *Smelting Materials Such As Lead-Tin Residues.* Roasting and smelting material comprising $PbSO_4$, SnO_2, and Cu compounds including powdery materials comprises extensively sintering same under oxidizing conditions.

(557) U. S. 2,343,270 (1944). C. E. Agnew, *Method of Processing Ore, Especially That Containing Iron.* An improvement is claimed in the processing of Fe ores, wherein the pulverized ore is heated to form a sinter cake which is broken up on grizzly bars and sized, and the undersize returned to be mixed with the fresh charge.

(558) U. S. 2,441,383 (1948). A. W. Babb, *Sintering Apparatus.* Into a sintering apparatus of the Dwight & Lloyd endless-track type is charged a mixture of finely divided material to be sintered and a combustible material which is burned. Air is drawn through the hot sinter to reduce the temperature from 540° C. (1000° F.) to 120° C. (250° F.) after which the cooled material is discharged.

D. Electrical Processes

i. Electrolysis of Salt Solutions

(559) U. S. 521,991 (1894). J. Sachs, and E. Huber, *Process of Manufacturing Metallic Powder.* Process of manufacturing metallic powder consists in interposing between suitable electrodes during electrolysis a metallic conductor in finely divided state maintained in motion during process.

(560) German 79,896 (1895). J. Sachs, *Method of Producing Metal Powders.* Method of producing metal powders comprises forming a metallic coating electrolytically on a conducting powder and moving the powder in the bath to bring it in contact with the anode.

(561) Brit. 17,671 (1896). L. Hoepfner, *Production of Porous Metals by Electrolysis.* Cohesive porous metals are obtained by electrolysis, so that the metal is precipitated alternately in a porous form and in a compact state; by such precipitation thin-walled pores are produced, while in the compact precipitation the walls of the pores become more solidified.

(562) German 87,430 (1896). L. Hoepfner, *Electrolytic Production of Porous Metallic Deposits.* Electrolytic production of porous metallic deposits comprises using two different current densities to deposit on the cathode metals of different densities.

(563) German 88,273 (1896). Elektrizitäts A. G., vorm. Schuckert u. Co., *Electrolytic Production of Metal Crystals.* The formation of the crystals is advanced by using an electrolyte containing oxidic compounds which solve again the separating metal by forming protoxide, *e.g.*, $CuCl + CuCl_2$ or $CuCl + FeCl_3$.

(564) U. S. 821,626 (1906). T. A. Edison (Edison Storage Battery Co.), *Process of Making Metallic Films or Flakes.* A Zn film is deposited on the cathode, a thin film of Co electrodeposited thereon, then Zn is dissolved in acid, while insoluble films or flakes are separated, and annealed in H_2 atmosphere.

(565) U. S. 865,688 (1907). T. A. Edison, *Process of Making Metallic Films or Flakes.* Films of metallic Co or Ni consist of deposits on the cathode of alternating layers of Cu and Ni or Co, or both. Resulting sheet is removed, cut into strips, agitated in a solution in which Cu is soluble, and Ni and Co are insoluble.

(566) U. S. 936,525 (1909). T. A. Edison (Edison Storage Battery Co.), *Process of Making Metallic Films or Flakes.* Flakes are made of Co or Ni or Co-Ni by depositing film of Cu on the cathode, then depositing Co or Ni on Cu, and dissolving Cu to expose the film of Ni or Co.

(567) French 415,760 (1910). J. Jourdan, *Electrolytic Production of Metal Powder.* Scrap metal is placed in perforated metal anode baskets surrounded by slotted metal cathodes. Current density is so regulated that metal powder forms, which falls to the bottom of the cell.

(568) U. S. 1,251,302 (1917). U. C. Tainton, *Electrolytic Recovery of Metals.* Process comprises precipitation of metals from solutions in an electrolytic cell by producing therein a rapid relative movement between the cathode and the solution, and removing the precipitated metal from the cathode.

(569) Brit. 124,006 (1919). B. Leech and Henry & Leigh Slater Ltd., *Electrolytic Preparation of Metal Paste.* Production of metal such as Sn is accomplished by using anodes which resist the conditions of electrochemical action and do not disintegrate nor pass into solution.

(570) French 511,428 (1920). B. Leech and Henry & Leigh Slater Ltd., *Electrolytic Production of Metals or Alloys in Pasty Form.* Method comprises using anodes formed of an active metal and of graphite, whereby the ratio of the surface of the active metal and of the resistance graphite can be changed.

(571) U. S. 1,334,419 (1920). U. C. Tainton, *Electrolytic Cell.* Electrolytic cell for precipitation of metals is made by method described in U. S. 1,251,302 (No.568).

(572) Canadian 213,965 (1921). H. H. Wikle, *Production of Metallic Powders.* Process comprises electrolysis of a salt solution in the presence of the metal, heating the solution to precipitate an oxide of the metal, and reducing it in a special atmosphere.

(573) German 340,567 (1921). B. Leech and Henry & Leigh Slater Ltd., *Electrolytic Production of Metal Pastes.* Process employs anodes consisting partly of active metal and partly of graphite which can not dissociate.

(574) German 347,220 (1921). M. A. Adam, *Electrolytic Production of Metals.* Comprises the use of a decomposition cell having a rotating drum as cathode, from which the precipitate is scraped off steadily, so that the electrolyte flows between the electrodes with a constant velocity.

(575) U. S. 1,365,140 (1921). M. A. Adam, J. Stevenson, A. T. Mabbitt and J. Fieldhouse, *Electrolytic Deposition of Metals.* Electrolytic deposition of metals in a non-coherent form is accomplished in a cell having a rotating cathode and employing a substantially uniform flow of electrolyte between the electrodes adapted to insure uniform composition within the cell.

(576) U. S. 1,397,008 (1921). A. McGall, *Finely Divided Metals.* Oxidizable metal such as Zn, Cu or Al are obtained in finely divided form by electrodeposition of the metal in spongy form from an immunized metal anode, *e.g.*, oil-coated Zn.

(577) Brit. 181,831 (1922). W. M. Gillespie and P. Buckley, *Electrolytic Production of Metal Powder.* Anode consists of metal to be deposited while cathode is either Al or Cu.

(578) German 362,181 (1922). A. McGall, *Electrolytic Production of Sponge Metal.* Process uses anode of metal to be produced as sponge which is protected by oil or fat against influence of the electrolyte.

(579) U. S. 1,440,502 (1923). J. Slepian (Westinghouse Electric & Mfg. Co.), *Electrolytic Production of Fine Metal Powders, and Colloidal Solutions.* A low-frequency current is passed between metallic electrodes, which are immersed in an electrolyte.

(580) U. S. 1,461,276 (1923). B. Leech (Henry & Leigh Slater Ltd.), *Apparatus for Electrolytic Production of Metallic Alloys.* Tin paste or sludge, for coating paper, of very fine particles, is deposited at the cathode, and has no adherence to itself or to the cathode.

(581) U. S. 1,462,421 (1923). R. E. Pearson and E. N. Craig (Metal Patents Ltd.), *Electrolytic Treatment of Metalliferous Materials.* Cr group metal powders are produced by electrolysis and a final reduction in H_2.

(582) Brit. 253,958 (1926). M. A. Adam, *Electrolytic Deposition of Metal in a Non-Coherent Form.* A rotating cathode is used to remove the deposit by means traversing the surface of the cathode in a direction at an angle to their rotation.

(583) Brit. 303,984 (1929). S. A. Tréfileries et Laminoirs du Havre, *Electrolytic Manufacture of Metal Powders.* Process consists of electrolizing a solution of a metallic salt containing carbonaceous reaction products such as glucose and H_2SO_4 in colloidal suspension in order to facilitate deposition of a spongy metallic mass; electrolytic Cu is an example.

(584) French 656,777 (1929). S. A. Tréfileries et Laminoirs du Havre, *Metallic Powders.* They are produced electrolytically by adding a carbonized material in the dispersed state to the bath. Thus fine Cu is obtained by adding glucose treated with H_2SO_4.

(585) French 722,319 (1931). S. A. Le Carbone, *Production of Metallic Powders.* Electrolytic production of powdered metals comprises using an alternative current with two electrodes of the same metal but with different cross sections and shapes, so that one of the electrodes acts as lead-in.

(586) German 520,835 (1931). S. A. Tréfileries et Laminoirs du Havre and E. Drouilly, *Manufacture of Metallic Powders.* In an electrolytic process carbon is mixed in colloidal state into the metallic bath.

(587) U. S. 1,799,157 (1931). E. Drouilly (S. A. Tréfileries et Laminoirs du Havre), *Manufacture of Metallic Powders by Electrolytic Means.* Process consists of electrolyzing a solution of metallic salt containing the carbonaceous reaction products of glucose and H_2SO_4 in colloidal suspension. Electrolytic Cu is an example.

(588) U. S. 1,804,924 (1931). E. Fitzpatrick, C. W. Clark, and P. A. Tiernan (Nichols Copper Co.), *Production of Fine Powder of High Purity.* Method of producing metal powders comprises disintegrating the metal by electrolysis to produce fine particles, removing the particle precipitate from the electrolyte, while preventing oxidation, and introducing them in a non-oxidizing medium into a vacuum dryer.

(589) U. S. 1,959,376 (1934). J. H. Lucas (Nichols Copper Co.), *Metals in Powdered Form.* Spongy metal, such as Cu, is deposited on a rotating cathode and scraped off.

(590) U. S. 1,977,173 (1934). W. M. Costa, *Electrolytic Production of Powdered Metals.* Apparatus for electrolytic deposition of metal powders has equal paths between the electrodes, so that a uniform current density is preserved, wherein the electrodes have smooth continuous surfaces.

(591) Brit. 441,921 (1936). R. Torikai, *Method of Manufacturing Fine Powder.* Production of a mixture of metal powders and C electrolytically provides for gases within a closed vessel.

(592) U. S. 2,053,222 (1936). J. H. Lucas, *Apparatus for Making Metal Powders such as Copper.* Apparatus for making metal powders combines an electrolyte bath, means for removing the metal deposit formed on the cathode without passing it through the bath, and means for conveying the deposit away in a non-oxidizing atmosphere.

(593) French 813,426 (1937). Siemens & Halske A. G., *Apparatus for Electrolytic Preparation of a Metal Powder With Soluble Anodes.* Apparatus has a vessel for electrolysis with soluble and insoluble anodes.

(594) French 814,174; 814,500 (1937). C. L. Mantell and C. Hardy, *Electrolytic Production of Metal Powders.* Sugar, glycerol, or urea are added to solution of metal salts during electrolysis of such metals as Fe, Ni, Cr, to obtain a deposit at the cathode in easily reducible form.

(595) U. S. 2,097,233 (1937). A. F. Meston (Research Corp.), *Apparatus for Electrodeposition of Metal Dusts and Other Materials in Pattern Form, as in Decorating Surfaces.* Invention provides means for depositing upon a surface a material in non-uniform but controllable manner; the material is suspended into a fluid in finely divided form.

(596) U. S. 2,099,873 (1937). M. M. Sternfels, *Process for Depositing Flaked Metal.* Process comprises depositing flaked metal from a plating bath on an endless belt which passes through the plating bath and into a second bath, while sharply bending the belt over a drum for removal of the flaked metal into the second bath.

(597) German 663,927 (1938). B. Claus, *Method for Producing Finely Divided Metals.* The cathode makes mechanical oscillations during the electrolysis, so that the deposited, dispersed metals are thrown back into the electrolyte.

(598) German 667,819 (1938). Siemens & Halske A. G., *Electrolytic Production of Zinc Powder.* Electrolytic production of Zn powder is accomplished by the addition of small quantities of a solution of metals, *e.g.*, Pb or Cd into the electrolyte.

(599) Italian 393,686 (1939). R. Pontelli, *Electrolytic Production of Metal Powders.* The powder is precipitated on the outer surface of a drum which is partly immersed in the electrolyte bath, and which has scrapers on its upper part.

(600) U. S. 2,216,167 (1940). J. S. Fisher (General Metals Powder Co.), *Method of Producing Metal Powders of Controlled Characteristics.* Process comprises immersing a plurality of electrodes in spaced relation in an electrolyte, passing current which is periodically reversed at intervals of 5 to 25 minutes, and vibrating the electrodes.

(601) Italian 387,923 (1941). I. G. Farbenindustrie A. G. and Siemens & Halske A. G., *Process and Apparatus for Electrolytic Production of Metal Powders, Particularly Zinc Powder.* Turbulent currents in the proximity of the cathodes are avoided by various means.

(602) Swedish 108,533 (1943). E. H. E. Johansson, *Method for Obtaining Oxide-free Metal Powder by the Electrolytic Process.* $NaNO_3$ or other nitrates, also hydroxides, are added to a concentrated chloride solution. For example, Fe powder is produced by adding the nitrate in an amount of about 3.75 g./kg. of $FeCl_2$ solution.

(603) U. S. 2,385,269 (1945). A. R. Globus, *Process of Electrolytically Extracting Metals.* Metal powder, such as Fe, is electrolytically extracted from ore in which the metal appears in high valence form; the metal is recovered as ions of lower valence.

(604) Brit. 580,710 (1946). Birmingham Small Arms Co. Ltd. and S. C. Wilsdon, *Electrolytic Powder.* Electrolytic deposition of metal on a metallic cathode is

formed by compacting a mass of powdered metal, and then mechanically reducing the cathode with the metal deposit to powder.

(605) Brit. 625,585 (1949). Reymersholms Gamla Industri A. B., *Electrolytic Production of Metals.* Highly pure Fe, Ni or Co is deposited from a formate bath. The deposits are not necessarily powdery, but powdered metals can be obtained by a wax cathode coated with graphite or bronze powder.

(606) U. S. 2,458,908 (1949). J. H. Jacobs (Crimora Research & Development Corp.), *Method of Stripping Electrodeposited Manganese.* Method of stripping electrodeposited manganese from a stainless steel cathode plate is carried out by heating the plate to 350° C. (660° F.) for 15 min. to 2 hours in a partial vacuum. The deposited metal is then broken from the cathode plate in the form of large flakes, that can be pulverized or otherwise processed.

ii. Electrolysis of Fused Salts

(607) U. S. 1,821,176 (1931). F. H. Driggs (Westinghouse Lamp Co.), *Method of Preparing Rare Refractory Metals.* Cr and other refractory metal powders are deposited from a bath of $CaCl_2$ and an ionizable Cr compound.

(608) U. S. 1,835,025 (1931). F. H. Driggs and W. C. Lilliendahl,(Westinghouse Lamp Co.), *Method of Preparing Rare Refractory Metals.* Powders of the metals of group 4 of the periodic table are deposited from a bath of alkali metal chlorides and a double halide compound of the desired metal.

(609) U. S. 1,842,254 (1932). F. H. Driggs (Westinghouse Lamp Co.), *Preparation of Rare Metals.* Rare metal powder, such as U, is prepared by electrolytic decomposition of a double halogen compound thereof in solution in a bath of alkali halogen compounds.

(610) U. S. 1,861,625 (1932). F. H. Driggs (Westinghouse Lamp Co.), *Preparation of Rare Metals.* Powdered rare metals, such as U, are deposited on a removable floating type cathode from a fused bath of alkali and alkaline earth halides containing a quadrivalent halide of the rare metal.

(611) U. S. 1,874,090 (1932). F. H. Driggs (Westinghouse Lamp Co.), *Electrolytic Production of Refractory Metal Powder.* In the electrolytic production of refractory metal powders in a fused bath containing an ionized salt of the refractory metal, *e.g.*, Ta, the particle size is increased by adding a proportion of an inonizable chloride compound, non-reactive with the metal.

(612) German 663,927 (1938). B. Claus, *Production of Dispersed Metals.* Electrolytic method for the production of dispersed metals comprises exerting on the cathode mechanical vibrations of high frequency, if the cathode consists of metals, such as Ta or Al, which are difficult to galvanize.

(613) U. S. 2,151,599 (1939). G. Jaeger (Deutsche Gold- & Silberscheideanstalt), *Electrolytic Production of Metals.* In the electrolysis of molten salts the metals are deposited on the cathode in substantially non-coherent form.

(614) U. S. 2,374,762 (1945). R. I. McNitt, *Method for Detecting Faulty Electrolytical Cell Operation.* It comprises producing light metals by electrolysis of a fused salt of light metal.

(615) French 916,924 (1946). E. H. E. Johansson, *Production of Metal Powders.* Electrolytic production of metal powders of Fe, Ni, and Cu comprises anodes consisting of the metal to be produced, and fused salts of metals less noble than the depositing metal, and an atmosphere enriched with Na, K or Li.

(616) U. S. 2,391,903 (1946). E. H. E. Johansson, *Method for the Production of Metallic Powder in Spherical Form.* Electrolytic production of spherical grain powders is accomplished by using a fused salt electrolyte, *e.g.*, KCl, with a less noble metal anion and cation capable of forming a volatile salt with the metal to be produced.

(617) Brit. 626,636 (1949). E. H. E. Johansson, *Electrolytic Reduction of Metal Oxides.* The oxides are reduced in a molten NaOH bath with diaphragm protection for the anode.

iii. Electrical Dispersion

(618) German 89,062 (1896). Soc. Civile d'Études du Syndicat Gerard, *Method of Producing Metal Powders.* Molten metal falling in thin particles is subjected to influence of electrical current of high intensity and low voltage.

(619) U. S. 700,399 (1902). P. Bary, *Process for Electrically Pulverizing Metals.* Molten metal in a stream is pulverized by having an intermittant electric current, with quick interruptions, flow through the stream.

(620) U. S. 1,299,565 (1919). C. Ellis, *Process of Electrically Preparing Catalysts for Hydrogenation.* Catalysts for hydrogenation are produced by electrical action on Ni and C.

(621) French 550,891 (1923). G. Boivin, *Method for Reducing Metals to Infinite Small Particles.* Metal powder is suspended in a liquid or in a gas and heated in a high frequency field, which produces ignition sparks between the particles to disintegrate them.

(622) French 774,100 (1934). R. Torikai, *Production of Very Fine Powder.* Involves electrical discharge between electrodes in a receptacle filled with gas under a pressure of 0.0005 mm. Hg.

(623) U. S. 2,103,623 (1937). H. Kott, *Electron Discharge Device for Bombarding Metals.* A method of electrically disintegrating and projecting deposits of metal comprises disposing the metal adjacent to, but insulated from, the electron emitting surface of a cathode, the anode arranged behind the cathode, both in an airtight enclosure, filled with ionizable gases.

(624) German 667,929 (1938). R. Torikai, *Production of Fine Metal Powders.* Between electrodes of the material for the powder occurs a discharge, to produce the powder which is taken away by a gas stream; the gas pressure is so selected that no joint deposit on the cathode is produced.

(625) German 678,799 (1939). E. Maier, *Production of Very Fine Metal Powder.* The jets of molten metal, passing out of nozzles, form part of an electric circuit, through which a current is conducted so high that the metal vaporizes in the air and can be condensed.

(626) Brit. 627,713 (1949). B. R. Lazarenko and N. J. Lazarenko, *Methods and Means for Producing Powders.* The manufacture of spherical metal particles by a process of electrical pulverizing is claimed to result from the material transfer in the spark discharge between electrodes placed in a liquid medium.

(627) U. S. 2,476,592 (1949). H. F. Fruth, *Cathode Deposition Apparatus.* An apparatus is disclosed for "cathode sputtering" into powders of metals, especially noble metals, such as Pt or Pt-Ir alloy.

E. Miscellaneous Processes (*e.g.*, Diffusion, Sintering, Alloy Disintegration)

(628) German 443,742 (1927). E. Seyfferth, *Production of Metal Alloy Powders by Diffusion.* The different metal powders are mixed intimately, and the mixture is heated up to annealing temperatures in inert gas or vacuum, in which it is cooled.

(629) U. S. 1,739,992 (1929). A. Schwarz, *Process of Working Up Mixed Shavings of White Metal.* Mixed shavings of white and red metals are separated by heating, and first drawing off greater part of molten white metal, cooling the residue, and scouring white metal by hard red metal to produce a fine white powder separable from red particles mechanically.

(630) Brit. 383,691 (1932). I. G. Farbenindustrie A. G., *Production of Magnetic Material.* Consists in consolidating and interdiffusing mixtures of two Fe metal powders, under sufficiently moderate conditions so that while the particles combine with each other to an alloy, this alloy does not become homogeneous.

(631) U. S. 2,082,362 (1937). J. L. Stevens, *Method of Producing Finely Divided Metallic Products.* Comprises forming an amalgam containing Cu and Hg, distilling the Hg under such conditions as to form a sponge and an easily disintegrated metallic residue which is ground.

(632) U. S. 2,200,369 (1940). L. G. Klinker (Johnson Bronze Co.), *Process of Making Metallic Molding Powder.* Metallic molding powders are produced by sintering, in reducing atmosphere, a mixture of a powdered metal and an oxide-coated powder, and regrinding.

(633) U. S. 2,299,043 (1942). M. Stern, *Method of Treating Light Metal Scrap.* It comprises keeping the scrap in motion in the furnace and contacting the lower portion of the scrap with the heated furnace wall, to liberate the oil, cooling the major upper portion of the scrap by introducing a cooling medium into the furnace which also takes away the oil from the furnace, and disintegrating the scrap into a fine powder.

(634) Brit. 555,983 (1943). Sandvikens Jernverks Aktiebolag, *Manufacturing Sintered Molded Bodies.* Consists in subjecting a metal or alloy to a treatment causing intercrystalline corrosion to the extent that metal is disintegrated to a powder, suitable for molding and sintering.

(635) Brit. 563,066 (1944). J. Sacek, *Metal Flakes and Powder.* They are produced by heating coarse granules by means of a low-voltage high-intensity electric source near to the melting point immediately before or while they are subjected to a rolling action to make fine powders.

(636) Brit. 574,583 (1946). Telephone Manufacturing Co. Ltd. and L. H. Paddle, *Metallic Alloys.* They are produced by mixing different metal powders, *e.g.* 81% Ni, 17% Fe, 2% Mo, compressing, heating to a temperature at which diffusion occurs, but below the melting points of the constituents for a time sufficient to ensure a complete interdiffusion of alloy constituents, and then reducing the cooled mass to powder.

(637) U. S. 2,452,665 (1948). W. J. Kroll and F. E. Bacon (Electro Metallurgical Co.), *Process for Separation of Metals.* Comprises contacting at elevated temperatures a solid alloy of metals having different affinities for Cl with an anhydrous chloride of a metal having lesser affinity for Cl than one, but greater affinity than another metal of the alloy.

2. TESTING METHODS AND EQUIPMENT

(638) U. S. 2,019,507 (1935). P. S. Roller, *Apparatus for Fractionating Finely Divided Material.* In the design of a suitable apparatus it must be considered that a particle finds itself in a field of force from which it must be separated by a sufficient momentum; since the momentum is constant in its direction, it is necessary to circulate the powder, to expose fresh portions to the inlet air.

(639) U. S. 2,361,946 (1944). R. C. Johnson, and R. Marchant (Minnesota Mining & Manufacturing Co.), *Electrostatic Separation of Particles.* A screening process is claimed for separating and classifying and effecting size grading of a mixture of dense granular particles of a generally uniform kind in which substantially all particles possess approximately the same electrical characteristics.

(640) U. S. 2,379,158 (1945). P. R. Kalischer (Westinghouse Electric & Mfg. Co.), *Particle Size Determination.* An apparatus for determining particle size characteristics of powdered materials based on sedimentation.

(641) U. S. 2,389,701 (1945). E. C. Truesdale (New Jersey Zinc Co.), *Pneumatic Sizing.* Process comprises a settling chamber, means for forcing a stream of gas upwardly through a blowing tube, an unpright tapered stream-directing baffle, means for introducing powder to be sized into the blowing tube, and means for withdrawing a fine fraction.

(642) U. S. 2,392,636; 2,392,637 (1946). R. E. Boehler (Universal Atlas Cement Co.), *Method and Apparatus for Determining Total Surface in Granular Bodies.* A method is claimed for determining the fineness of almost any finely comminuted substance.

(643) U. S. 2,392,765 (1946). E. D. Reeves (Standard Oil Development Co.), *Method of Controlling Flow of Powder.* A method is claimed for controlling flow of powdered materials from a container to a zone in which the powdered material is utilized which comprises placing powdered material under a substantially constant superatmospheric pressure and forcing the material upward through a tube extending through the top of the container, adding a gasiform fluid at a substantially constant rate to powdered material and using the pressure drop across a restricted orifice in the tube to actuate a control valve ahead of the orifice.

(644) Brit. 598,273 (1948). Dr. Rosin Industrial Research Co. and W. Deutsch, *Apparatus for Volume Measurement of Powders.* Sample is placed into a container connected with a vessel having the same volume, and both are evacuated; after restoring atmospheric pressure in the sample container and sealing it off, the pressure in the two vessels is equalized. The volume of the sample can then be derived from the difference between the original vacuum and the equalizing pressure.

3. SPECIAL PRODUCTION METHODS AND EQUIPMENT AND COMPOSITION OF POWDERS

A. Metal Powders

i. Refractory Metals (Tungsten, Molybdenum, Tantalum, Columbium, Vanadium, Zirconium, Titanium, Thorium, Chromium, Uranium)

(645) Brit. 11,848/1847 (1847). R. Oxland, *Manufacture of Metallic Alloys.* Tungstate of soda is mixed with charcoal dust and exposed to a strong red heat for about one hour in a carbon crucible, to reduce the tungstic acid to the metallic form.

(646) U. S. 930,027 (1909). F. M. Becket, *Production of Tungsten.* Si and B are used to reduce the WO_3 in an electric furnace.

(647) German 221,899 (1910). Zirkon-Glühlampenwerk Dr. Hollefreund & Co., *Reduction of Tungstic Oxide.* The product is first reduced with Zn and then further treated with Mg or Al.

(648) U. S. 946,551 (1910). W. Mafert, *Paratungstate Reduction.* Sodium paratungstate is mixed with C and heated to redness in revolving furnace until CO_2 starts to evolve, then H_2 or water gas is admitted until complete reduction is reached.

(649) U. S. 950,869 (1910). J. Schilling, *Thermal Decomposition of Tungstates.* When paratungstate of ammonium is heated in a non-oxidizing atmosphere of NH_3 or N_2, the ammonium radical of the compound is dissociated into H and N, and the nascent H reduces the tungstate to W.

(650) U. S. 960,441 (1910). E. Thomson (General Electric Co.), *Production of Tungsten.* WO_3 is reduced with H_2.

(651) U. S. 964,868 (1910). C. M. Johnson (Crucible Steel Co.), *Reduction of Tungstic Oxide.* WO_3 and C are charged in separate successive layers, whereby the CO developed reduces WO_3.

(652) U. S. 977,096 (1910). C. M. Johnson (Crucible Steel Co.), *Reduction of Tungsten Ore by Carbon.* Treating of a S-containing W-ore by roasting it, then mixing the roasted ore with C and reducing the mixture in a furnace with the aid of the gaseous carbon oxides formed.

(653) Brit. 2,759/1910 (1911). British Thomson-Houston Co., Ltd., *Dry Processes of Extracting and Refining Tungsten and Molybdenum.* Method consists in slowly cooling a coherent mass of W or Mo powder, sintered at very high temperature.

(654) Brit. 8,031/1910 (1911). British Thomson-Houston Co., Ltd., *Manufacture of Tungsten Powder.* Manufacture of coarse W powder consists in packing a fused quartz tube with pure WO_3 and reducing the oxide by heating the tube to 1400° C. (2550° F.) in H_2 for 5-15 hrs.

(655) German 231,657 (1911). Wolfram Lampen A. G., *Treatment of Pertungstic Acid.* A solution of $WO_3 \cdot H_2O_2 \cdot H_2O$ in alcohol is electrolyzed to produce pure W at a temperature of 25° C. (77° F.), 10-20 volts, the cathode being Pt, Ni or Cu.

(656) German 237,014 (1911). Wolfram Lampen A. G., *Treatment of Tungsten Chloride.* By electrolyzing a solution of WCl_6 in acetone, W is deposited on the cathode of Pt, Ni or C.

(657) German 239,877 (1911). Wolfram Lampen A. G., *Production of Tungsten Powder for Filaments.* Tungstic acid is mixed with P and heated in inert atmosphere.

(658) U. S. 985,386 (1911). F. Blau (General Electric Co.), *Production of Divided Refractory Metals.* Oxygen compounds of W are reduced by excess quantity of gaseous reducing agents at low temperature.

(659) German 246,182 (1912). C. M. Johnson, *Reduction of Tungstic Oxide. Cf:* U. S. 964,868 (No. 651).

(660) German 247,993 (1912). Electric Furnaces & Smelting Ltd., *Production of Tungsten.* A mixture consisting of 75% WO_3, 7-10% ferrosilicon, 14-18% CaC_2 is fused in an electric furnace, to produce tungsten.

(661) German 249,314 (1912). J. Schilling, *Production of Filaments.* Ammonium tungstate is decomposed in a reducing atmosphere of H_2, whereby the products of decomposition are used to form the reducing atmosphere, and fine W powder results.

(662) U. S. 1,019,581 (1912). H. Zerning, *Reduction of Tungstic Oxide.* The product is reduced with Zn and then further treated with Mg or Al.

(663) Brit. 8,720/1912; 9,981/1912 (1913). C. H. Fischer, *Process for Rendering Metals Ductile.* Dry processes of extracting W and other refractory metals are claimed.

(664) Brit. 27,859/1912 (1913). C. Gladitz, *Manufacture of Tungsten.* A process for the manufacture of the allotropic form of W is claimed in which a flaky precipitate of WO_3 free from colloidal forms is reduced in a furnace in H_2 at 850° C. (1560° F.) for 4½ hours and then immediately cooled.

(665) German 261,819 (1913). Badische Anilin & Soda-Fabrik, *Reducing of Tungstic Acid.* Method comprises using H_2 at 500-600° C. (930-1110° F.) under 80 atm. pressure. If tungstic acid is mixed with reducible oxide of another metal, an alloy is obtained.

(666) Brit. 1,915/1913 (1914). British Thomson-Houston Co., Ltd., *Powdered Tungsten.* Method of manufacturing powdered W comprises incorporating with WO_3 a quantity of a solution of a rare earth compound, heating the mixture in an oxidizing atmosphere and then reducing it.

(667) German 270,194 (1914). H. Leiser, *Manufacture of Heavy Crystalline Tungsten and Molybdenum Powder.* Metal salts are treated with NH_3, compressed, heated to 1200° C. (2190° F.) for conversion of amorphous particles into crystalline bodies.

(668) German 276,659 (1914). P. Schwarzkopf, *Production of Very Fine Tungsten Powder.* Method comprises reduction of W-oxides by a reducing gas which flows with very high velocity above the powder, to lower the partial pressure of O.

(669) U. S. 1,088,909 (1914). H. Kuzel and E. Wedekind, *Reduction of Tungstic Oxide.* W powder is produced from the oxide by treating with Ca in vacuum.

(670) Brit. 14,381/1914 (1915). C. Trenzen, *Tungsten Powder.* Method of rendering W ductile provides for treating powdered metal with alkaline nitrites.

(671) U. S. 1,130,197 (1915). R. Rafn (General Electric Co.), *Tungsten Powder.* WO_3 is first heated in NH_3 gas, and then in H_2 at high temperature.

(672) Brit. 16562/1915 (1916). J. C. Butterfield and A. Ashworth, *Production of Tungsten from Scheelite.* The mass resulting from the reducing operation is subjected to mechanical separation by gravity to separate the metallic W.

(673) U. S. 1,175,693 (1916). C. Bosch and A. Mittasch (I. G. Farbenindustrie A. G.), *Reduction of Tungstic Acid.* Tungstic acid can be quickly reduced by H_2 at 600° C. (1110° F.) under a pressure of 80 atm.; if the tungstic acid is mixed with a reducible oxide of an other metal, an alloy is obtained.

(674) U. S. 1,196,699 (1916). F. G. Keyes and R. B. Brownlee (Cooper-Hewitt Electric Co.), *Production of Tungsten Powder.* Apparatus consists of a Pt–crucible, filled with fused sodium tungstate, a porous cap of presintered W-powder, which dips into the fused salt material, and a cathode dipping in the fused salt in the porous cap.

(675) U. S. 1,202,534; 1,202,535 (1916). F. G. Keyes and R. B. Brownlee *Production of Tungsten Powder.* Method consists of heating WO_3 to 2000° C. (3630° F.), thereby producing a lower oxide or a mixture of oxides which conducts electricity readily even at ordinary temperatures; by electrolyzing a melt of the lower oxide, W is obtained.

(676) U. S. 1,224,242 (1917). O. Voigtlander, *Reduction of Tungsten Ore.* WO_3 and Al are mixed and heated in a furnace to a high temperature for reaction; the resulting W metal conforms to shape of the containing vessel.

(677) U. S. 1,235,655 (1917). H. E. Cleaves, *Process for Treating Alloys.* Pure W is obtained from finely subdivided ferrotungsten by subjecting the latter to the action of a H-halide, at a temperature to form an Fe-halide.

(678) Brit. 113,839 (1918). M. J. Insull, *Electric Furnace for Production of Tungsten Powder.* The furnace for reduction of WO_3 to W has a refractory tube provided with a thin Ni-sheet lining.

(679) Brit. 119,117 (1918). O. Bertoya, *Tungsten Powder.* Method of manufacture consists of reduction of WO_3 by H_2 under moderate pressure during a continuous process through an externally heated retort, through which the material travels downward by virtue of the physical changes affecting the frictional resistance, resulting from progressive reactions.

(680) U. S. 1,260,940; 1,271,760 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Electric Furnace for Reduction of Tungstic Oxide.* Furnace consists of a tube of refractory material surrounded by a heating element, a Ni protecting lining and means for supporting WO_3 to be reduced within the lining.

(681) U. S. 1,263,598 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Tungsten Reducing Furnace.* Method comprises heating H_2 to the temperature at which WO_3 is reduced, so that the released vapor will have less tendency for condensation.

(682) U. S. 1,270,842 (1918). F. G. Keyes (Cooper-Hewitt Electric Co.), *Production of Metallic Tungsten Powder.* Method comprises reducing mixture of powdered WO_3 and alkali metal.

(683) U. S. 1,289,896 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Tungsten Reducing Furnace.* Furnace provides for heating WO_3 in H_2, rapidly circulating to carry off the moisture in a furnace of tubular type, through which the boats with WO_3 are traveling.

(684) U. S. 1,293,117 (1919). F. G. Keyes (Cooper Hewitt Electric Co.), *Production of Tungsten Powder.* The electrolyzing bath consists of dissolved WO_3 in H_3BO_3.

(685) Brit. 155,600 (1920). C. J. Head, *Production of Tungsten Powder from Tungstates.* Ground sodium tungstate is mixed with NH_4Cl and C, both in excess, and the mixture is heated in a vessel, to produce W powder.

(686) Brit. 155,851 (1921). British Thomson-Houston Co. Ltd., *Method of Producing Tungsten.* Method of producing W powder comprises adding to an alkaline tungstate a solution containing a silicate or tantalate or H_3BO_3; then drying and igniting the precipitate to reduce it to metal.

(687) French 539,234 (1921). J. L. Berthet, *Treatment of Tungstate.* Method consists of electrolyzing a solution of potassium or sodium tungstate with Hg, to obtain an alloy of W-Hg, from which Hg is recovered.

(688) U. S. 1,373,038 (1921). H. C. P. Weber, *Treating Chloride of Tungsten.* Method comprises mixing the chloride with Fe and heating to 1200° C. (2190° F.) to form W, while the Cl combines with Fe to $FeCl_3$; Fe and Cl may be regenerated by treating with C.

(689) U. S. 1,388,857 (1921). D. J. Giles and J. E. Giles, *Process of Extracting Tungsten.* It comprises forcing a reaction between the ore and an alkaline solution to produce an alkaline solution of W, separating it from the gangue, removing the impurities, and then recovering W.

(690) Brit. 187,375 (1922). Aktien-Gesellschaft B. Felder-Clement, *Reduction of Tungstic Oxide.* The oxide is charged and rammed tightly in a crucible, and Al is introduced and the crucible heated to 1700° C. (3090° F.). When the reaction is completed the W is formed on the bottom of the crucible.

(691) French 539,234 (1922). J. L. Berthet, *Electrolytic Production of Tungsten.* Method comprises the electrolytic formation of an alloy of W with Hg, and an alloy of W with Na or K, then separating these alloys by their specific gravities, and finally decomposing the W alloy with Hg by vaporizing the latter, whereby powdered metal product results.

(692) U. S. 1,427,187 (1922). W. F. Bleecker (Tungsten Products Co.), *Reduction of Tungstic Oxide.* A mass of WO_3 having voids or passages for the circulation of a gas is heated in presence of a reducing agent.

(693) Brit. 183,816 (1923). N. V. Philips' Gloeilampenfabrieken, *Tungsten Powder.* Process for manufacturing W powder comprises starting from complex tungstic acid, heating, powdering, and reducing the same to W powder.

(694) German 379,317 (1923). N. V. Philips' Gloeilampenfabrieken, *Production of Tungsten Powder.* A complex acid of W or its salts is reduced to metal powder.

(695) German 381,205 (1923). J. Winsch, *Furnace for Production of Tungsten Powder.* Consists of a turning furnace in which the metal oxide is introduced in boats in the form of cartridges which are moved through the furnace.

(696) German 381,424 (1923). Durelco Ltd., *Reduction of Tungsten Trioxide.* WO_3 is electrolytically reduced in the presence of an electrolyte which can not be dissolved, to form on the cathode a low-value oxide, which then is reduced to metal.

(697) U. S. 1,508,629 (1924). G. D. Van Arsdale, R. T. Sill and H. A. Sill, *Method of Producing Molybdenum.* Mo_2O_3 is deposited on the cathode, which requires half the reducing agent needed for MoO_3, and which, when reduced, produces Mo powder.

(698) Brit. 236,152 (1925). N. V. Philips' Gloeilampenfabrieken, *Production of Tungsten Powder.* An alkali-metal tungstate is electrolyzed at 900° C. (1650° F.) to which both an alkali oxide or hydroxide is added, to prevent the formation of tungsten bronze, caused by excess of WO_3 in the bath.

(699) Brit. 236,153 (1925). N. V. Philips' Gloeilampenfabrieken, *Production of Tungsten Powder.* Method comprises using lithium tungstate and maintaining its fusion at 900° C. (1650° F.) with a current density of 75-100 milliamp per cm^2, at 0.08 volt.

(700) Dutch 13,749 (1925). N. V. Philips' Gloeilampenfabrieken, *Preparation of Tungsten Powder.* WO_3 is dissolved in 1:5 NH_4OH solution, containing 5-20% as much K_2CO_3 as the weight of WO_3 and solution is evaporated. WO_3 is formed from the mixed crystals by heating in a quartz crucible and the oxide reduced in H_2.

(701) French 589,601 (1925). N. V. Philips' Gloeilampenfabrieken, *Production of Tungsten Powder.* Method consists of electrolysis of a molten alkaline tungstate or lithium tungstate.

(702) German 432,517 (1926). N. V. Philips' Gloeilampenfabrieken, *Production of Tungsten Powder.* Method comprises electrolysis of molten alkali wolframite.

(703) U. S. 1,585,497 (1926). A. Just, *Powder Production for Ductile Tungsten.* WO_3 serving as derivation material for W powder is fused preliminary to reduction, to make a more compact sintered rod.

(704) U. S. 1,602,542 (1926). J. W. Marden (Westinghouse Lamp Co.), *Reduction of Tungstic Oxide.* Process is carried out with Mg in a bomb which is heated to 600° C. (1110° F.) to start the reaction, which then progresses without external heating.

(705) Brit. 269,947 (1927). Metallwerk Plansee, *Molybdenum and Tungsten Powder.* Process for producing molybdic or tungstic acid from ores comprises melting the ore and evaporating the acid.

(706) Canadian 275,882 (1927). W. B. Gero (Canadian Westinghouse Co.), *Tungsten Powder.* Method of production comprises mixing with WO_3 1% cesium and reducing the oxide by H_2 at elevated temperature.

(707) U. S. 1,648,954 (1927). J. W. Marden (Westinghouse Lamp Co.), *Uranium Powder.* Oxidation of U powder is prevented by alloying it with Al powder, which during later heat treatment distils off.

(708) U. S. 1,659,205 (1928). E. A. Lederer (Westinghouse Lamp Co.), *Method of Producing Refractory Metals.* Consists in heating a sulfide of the metal in vacuum to the decomposition temperature and removing the volatilized sulfur.

(709) U. S. 1,704,257 (1929). J. W. Marden, (Westinghouse Lamp Co.), *Reduction of Tungstic Oxide.* Ca is employed as reducing agent with a halide of alkaline earth metal, and the reduction is carried out in a bomb from which O and Ni are excluded.

(710) U. S. 1,728,940 (1929). J. W. Marden (Westinghouse Lamp Co.), *Method of Producing Uranium.* Stable U is formed by reducing U-oxides with Ca in the presence of $CaCl_2$; the salts of reaction are removed with solvents.

(711) U. S. 1,738,669 (1929). M. N. Rich (Westinghouse Lamp Co.), *Reduction of Tungstic Oxide.* Reduction is carried out in an hermetically sealed vessel with a mixture of $CaCl_2$ and a Ca-Mg alloy.

(712) U. S. 1,741,955 (1929), M. N. Rich (Westinghouse Lamp Co.), *Method of Obtaining Chromium.* Cr metal powder is produced by heating Cr_2O_3 and subjecting it to a strong, free flow of pure H_2.

(713) German 514,365 (1930). H. Hartmann, *Electrolytic Production of Tungsten.* Tungstic acid is introduced into a melt of alkali-phosphate, which is mixed only with free phosphoric acid for fluidity, and the electrolyte is agitated with electric current of 1 volt and 0.1 amp./cm.^{2} to precipitate W.

(714) German 532,991 (1931). E. Pokorny (I. G. Farbenindustrie A. G.), *Tungsten.* W powder is prepared from ores such as wolframite by reduction with H_2 mixed with a small quantity of elementary halogen above 800° C. (1470° F.),

(715) U. S. 1,796,026 (1931). C. V. Iredell, *Recovery of Tungsten.* Dilute HCl is added to the mother liquor resulting from the crystallization of alkali tungstate and constantly stirred until an alkalinity of from 0.3-0.7% is obtained, whereupon WO_3 is precipitated which is then reduced to W powder.

(716) U. S. 1,799,403 (1931). C. W. Balke (Fansteel Products Co.), *Process of Obtaining Tantalum.* A fused bath of potassium fluotantalate and tantalic acid is electrolyzed to produce a mass which is ground and purified, resulting in Ta powder containing 1/10 of 1% C.

(717) U. S. 1,815,054 (1931). F. H. Driggs and W. C. Lilliendahl (Westinghouse Lamp Co.), *Method of Producing Tantalum by Electrolysis.* Ta powder is produced by depositing it from a fusion mixture of alkali metal halides, a double alkali Ta halide compound, and an ionizable O-containing Ta compound soluble in the halides.

(718) U. S. 1,821,176 (1931). F. H. Driggs and J. W. Marden, *Production of Tungsten Powder.* The fused bath is composed of an alkali-earth metal chloride, containing a proportion of a double halide of W, and W-oxides.

(719) U. S. 1,877,961 (1932). E. Pokorny, *Treatment of Wolframite.* Method comprises subjecting the ore to the action of a mixture of H and Cl in ratio 8:1, so that Fe and Mn are volatilized in form of chlorides, whereas the W is reduced.

(720) U. S. 1,885,701; 1,885,702 (1932). C. G. Fink and F. L. Jones, *Treatment of Tungstate.* Sodium tungstate or ammonium paratungstate is electrolysed with a Pt anode and brass cathode; the W plating can proceed only up to a certain thickness and then stops, but if solution contains $NiCO_3$ the plating process continues.

(721) German 589,987 (1933). I. G. Farbenindustrie A. G., *Production of Chromium Powder.* By agitation of $CrCl_3$ with Mg and heating it at a temperature above the melting point of the chloride, whereupon the $MgCl_2$ formed is filtered.

(722) U. S. 1,905,882 (1933). C. W. Balke (Fansteel Products Co.), *Producing Metallic Columbium.* The process comprises fusing Cb-bearing ores with KOH, leaching the fused mass and treating the solution with HF to remove Ta; then converting the Cb compound by electrolytic reduction to Na-columbate to effect a separation from Sn and W. Cb powder is separated from the salt by mechanical means and washing.

(723) U. S. 1,968,490 (1934). L. D. Jensen, *Manufacture of Pulverulent Chromium.* Cr as a fine powder is produced by electrolyzing a Cr-plating bath containing a high concentration of CrO_3 with a cathode made of a metal not attacked by the bath. The flakes are detached from the cathode and ground to a powder.

(724) German 609,501 (1935). N. V. Philips' Gloeilampenfabrieken, *Production of Zirconium.* Zr powder is produced by reduction of $Na_5Zr_2F_{13}$ with Na.

(725) Brit. 484,329 (1938). D. Gardner, *Manufacture of Tungsten from its Ores, Salts or Other Compounds of Tungsten.* A mixture of WO_3 and carbonization coke is heated in S-vapors and the resulting WS_3 is reduced by heating with Al in H_2.

(726) French 826,427 (1938). Deutsche Gold- & Silberscheideanstalt A. G., *Preparation of Titanium.* $TiCl_4$ is mixed with alkali earth metal in a bath and heated in H_2 at 800° C. (1470° F.).

(727) U. S. 2,107,277 (1938). M. M. Austin (Fansteel Metallurgical Corp.), *Tantalum Recovery from Scrap.* Ta-scrap is hydrogenated, ground and heated to 900° C. (1650° F.) while gases released from the powder are exhausted.

(728) Brit. 512,502 (1939). I. G. Farbenindustrie A. G., *Production of Chromium.* A process for the reduction of difficultly reducible oxides of the elements of the 2nd to 7th group of the periodic system, especially Cr, consists of subjecting the oxides to a heat-treatment with C and H under reduced pressure.

(729) U. S. 2,142,694 (1939). C. G. Maier (Great Western Electro-Chemical Co.), *Reduction of Chromium Chloride.* Reduction of $CrCl_3$ to Cr is accomplished with dry H_2 at 775-850° C. (1425-1560° F.), removing the HCl and water vapor by passing the H_2 over activated C and returning the purified H_2.

(730) U. S. 2,145,745 (1939). H. H. Armstrong and A. B. Menefee, *Electroplating with Tungsten.* The process involves the use of soluble WC anodes, dissolving WO_2 in an aqueous acid fluoride bath, adding an acid-soluble salt of a metal of group 8 of the periodic system, to be alloyed with W, and maintaining the temperature of the bath with a current density of 14 amp./ft^2.

(731) German 704,933 (1941). I. G. Farbenindustrie A. G., *Zirconium Powder by Thermal Reduction of Chloride.* Equal quantities of $ZrCl_4$ and KCl are heated with Mg filings to 750° C. (1380° F.). The major part of fused salts is then decanted and remainder leached out with moderately dilute HCl, leaving Zr powder.

(732) U. S. 2,255,210 (1941). J. J. Furey (Electro Metallurgical Co.), *Treatment of Molybdenum Ore.* Mo is separated from scheelite ore by treating with HCl in presence of ferrosilicon.

(733) German 725,828 (1942). I. G. Farbenindustrie A. G., L. Schlecht and M. Jahrstorfer, *Method of Producing Chromium.* Method of producing powdered Cr or Cr-alloys comprises reducing Cr-oxides with H and C under subatm. pressure.

(734) German 736,604 (1943). I. G. Farbenindustrie A. G., L. Schlecht, and M. Jahrstorfer, *Reduction of Vanadium and Uranium.* Application of the method of German 725,828 (No. 733) to the production of V or U. For example, 45 parts UO_2 are mixed with 6 parts charcoal and 476 parts MoO_3 and heated in H_2 for 10 hours

to 1300° C. (2370° F.); the sintered mass then consists of 10% U and 90% Mo.

(735) U. S. 2,273,834 (1942). G. F. Comstock, V. V. Efimoff (Titanium Alloy Manufacturing Co.), *Powdered Metallic Titanium.* Method of production comprises heating $TiCl_4$ with Na in a vessel in the presence of a minor quantity of TiO_2, TiN, or cyanonitrite, and crushing the product.

(736) U. S. 2,341,844 (1944). C. G. Maier, *Process for Treating Chromium Chloride.* Method of producing Cr metal consists of reducing violet $CrCl_3$ by H_2.

(737) Japan 162,743; 162,745 (1945). Sumitomo Communication Industries Co., *Molybdenum by Reduction of Ammonium Molybdate.* Minute crystals of $(NH_4)_2MoO_4$ are heated to 350-550° C. (660-1020° F.) in a stream of NH_3 to produce $Mo_5N_6H_3O_5$, which then is reduced with H to Mo.

(738) U. S. 2,367,263 (1945). H. T. Brown (Standard Oil Co.), *Transferring Molybdenum.* Transferring Mo from a spent catalyst to a fresh solid catalyst by vaporization and condensation on a catalyst carrier is claimed by a method that also recovers the Mo in powder form.

(739) U. S. 2,384,301 (1945). C. G. Harford (Arthur D. Little Inc.), *Electrolytic Deposition of Tungsten.* A process of electrolysis comprises electro-depositing W from an undivided cell containing an aqueous electrolyte.

(740) French 915,343 (1946). Societé De Produits Chimiques des Terres Rares, *Zirconium Powder.* Method of manufacture comprises reacting zircon-sand with Ca in proportion 48:37 at 1000° C. (1830° F.) for 1-3 hrs. under vacuum.

(741) Japan 172,746 (1946). N. Watanabe, *Titanium Removal from Tantalum.* The ore is treated with HCl to dissolve Ti without dissolving the powdered Ta.

(742) Japan 172,858 (1946). M. Maeda, *Metallic Tungsten.* W is prepared as $5\ (NH_4)_2O{\cdot}12WO_3{\cdot}H_2O$ and heated under non-oxidizing conditions to W_4O_{11}, which is reduced with H_2 to W.

(743) U. S. 2,394,362 (1946). B. Burwell (United States Vanadium Corp.), *Treatment of Tungsten Ores.* Process relates to recovery of W from low-grade W-ores substantially free from Sn.

(744) U. S. 2,398,114 (1946). R. F. Rennie (Westinghouse Electric Corp.), *Reduction of Molybdenum-Trioxide.* Powdered MoO_3 is mixed with H_2O, granulated, dried and treated for 2 hours at 630° C. (1160° F.) with a slow stream of H_2 diluted with steam. The steam is then cut off, temperature raised to 1040° C. (1840° F.) and after about 2 hours, MoO_2 is reduced to metal.

(745) U. S. 2,402,084 (1946). R. F. Rennie (Westinghouse Electric Corp.), *Continuous Reduction of Molybdenum Compounds.* Powdered MoO_3 in boats is reduced by H_2 to produce pure Mo which may be in granular form when reduction is completed.

(746) U. S. S. R. 65,269 (1946). P. M. Porkhunov and I. A. Alekseev, *Recovery of Tungsten Waste.* By treating the waste with molten niter, W is converted into water soluble salts, while the accompanying metals form insoluble oxides.

(747) U. S. S. R. 66,560 (1946). S. A. Prechistenskii, *Re-treating Tungsten Waste.* Pieces of W-alloy scrap are treated in molten niter, to form soluble salts, while the accompanying metals form insoluble oxides; the furnace is lined with magnesite, and the outside is cooled.

(748) Brit. 595,197 (1947). R. C. Archibald and R. A. Trimble, *Recovery of Tungsten or Molybdenum.* Compounds of W, Mo, U are treated with H_2S at 500° C. (930° F.) to convert them into sulfides, which then are ground to 120 mesh and oxidized by chlorates or chromates.

(749) French 920,631 (1947). Westinghouse Electric International Co., *Manufacture of Thorium.* Method comprises mixing ThO_2 with Ca which is molten in an inert gas, so that it reacts with the oxide to set free the Th, followed by freezing the mass to produce powdered Th.

(750) U. S. 2,414,601 (1947). W. C. Lilliendahl (Westinghouse Electric Corp.), *Tungsten Compounds.* Method of removing undesirable metallic elements including Fe from aqueous solution of an alkali metal tungstate prior to the processing into the metal powder is claimed.

(751) U. S. 2,427,360 (1947). W. J. Kroll and F. E. Bacon (Electro Metallurgical Co., *Method of Treating Columbium and Tantalum Materials.* Process comprises separate recovery of Cb and Ta from mixture containing the pentoxides.

(752) U. S. 2,429,671 (1947). F. Cuvelliez, *Treatment of Materials Containing Tantalum and Columbium.* Cb may be separated from Ta in the ore by roasting the ground material with CaO at 800-1200° C. (1470-2190° F.) in air. Mixture is then heated in Cl-containing atmosphere at 800-1000° C. (1470-1830° F.) in a closed container, causing decomposition of the salt, and yielding the metal powder.

(753) Brit. 598,331 (1948). Electro Metallurgical Co., *Production of Chromium Powder.* Pure $CrCl_3$ is reacted with NH_3 to form a nitride by subliming $CrCl_3$ directly into the nitriding chamber at 600° C. (1110° F.). CrN is then crushed and heated under high vacuum at 1600° C. (2910° F.) to decompose into Cr and N.

(754) Brit. 600,833 (1948). Comp. De Produits Chimique Alais, Froges & Camarque, *Vanadium and Ferrovanadium from Bauxites.* Salts containing V_2O_5, P_2O_5, As_2O_5, Na_2O are recovered from decomposed aluminate liquors from the Bayer process by crystallization; washed to eliminate Na aluminate, the salts containing P and As are filtered, and V is precipitated as ammonium metavanadate.

(755) Brit. 606,930 (1948). Westinghouse Electric International Co., *Manufacture of Thorium. Cf:* Fr. 920,631 (No. 749).

(756) Canadian 450,289 (1948). W. J. Kroll (Electro Metallurgical Co. of Canada Ltd., *Chromium Powder.* $CrCl_3$ is treated with NH_3 to form NH_4Cl and CrN; NH_4Cl is treated with lime to regenerate NH_3, and the nitride is heated to 1600° C. (2910° F.) *in vacuo* to form Cr powder.

(757) U. S. 2,442,429 (1948). R. D. Nye and D. J. Demorest, *Extracting Uranium, Radium or Vanadium.* Ores are ground to 40 mesh, treated with alkali-carbonate and the Ra- or U-bearing fines are washed out. Wash liquor and sludge are treated with H_2SO_4 to precipitate a concentrate of V-values; the supernatant solution of a filtrate containing U- and Ra-values is made alkaline with caustic soda.

(758) U. S. 2,446,062 (1948). H. C. Rentschler and W. C. Lilliendahl (Westinghouse Electric Corp.), *Manufacture of Thorium.* Method consists of mixing ThO_2 with Ca, placing it in a Mo cup in a high-silica glass bulb; evacuating the bulb and introducing an inert gas; then heating the mixture to 800-900° C. (1470-1650° F.) to melt the Ca and to cause a reaction with the oxide, to liberate free Th; then cooling and drying it to powdered metal.

(759) U. S. 2,454,322 (1948). C.V. Iredell and R.J. Enrico (Westinghouse Electric Corp.), *Manufacture of Molybdenum.* Method comprises reducing a compound of MoO_3 and ammonium molybdate to an oxide lower than the trioxide, mixing it with a small percentage of B_2O_3, and reducing in H_2, whereby all B is removed as a hydride.

(760) Brit. 609,487 (1949). Westinghouse Electric International Co., *Reducing Ammonium Molybdate.* MoO_3 is reduced with H_2 to MoO_2 in presence of NH_3, which is driven off by steam; MoO_2 is reduced with H_2 in presence of steam to give pure Mo.

(761) Brit. 617,896 (1949). A. R. Globus, *Recovering Tungsten from Tungsten Carbides.* Scrap carbide is heated and exposed to a stream of an air–Cl–HCl mixture. The reaction is exothermic and the gas flow should be regulated to maintain 650° C. (1020° F.). W is volatilized and collected as a condensate.

(762) Brit. 623,160 (1949). Westinghouse Electric International Co., *Manufacture of Thorium.* Improvement on Brit. 606,930 (No. 755) consists in reducing a mixture of chloride and oxychloride with a large excess of Ca; the mixed chloride is prepared by precipitating ThOH from a nitrate solution by means of NH_3.

(763) Brit. 628,147 (1949). W. J. Kroll, *Method of Producing Zirconium.* Method comprises reaction of anhydrous gaseous $ZrCl_4$ with molten Mg in a He atmosphere. The Zr-salt is first dehydrated by wetting with $TiCl_4$ and evacuating at elevated temperature; He is then admitted, the Mg is melted and the $ZrCl_4$ is sublimed; Zr is heated *in vacuo* to distill off all excess Mg and $MgCl_2$.

(764) Brit. Appl. 7208/49 (1949). Dominion Magnesium Ltd., *Production of Titanium.* A substantially pure and ductile Ti in powder form is obtained by thermal reduction of TiO_2 in two stages, with Mg and Ca respectively.

(765) Brit. Appl. 15781/49 (1949). Battelle Memorial Institute, *Production of Refractory Metals.* Method comprises a continuous process for the manufacture of Ti or Zr by Mg reduction of the tetrachloride in the vapor phase, thus rendering an inert atmosphere unnecessary.

(766) U. S. 2,463,367 (1949). C. G. Fink, *Method of Producing Tungsten.* Pure crystalline grains of W are produced directly from oxidic W-ores and their concentrates by mixing the W-containing material with molten NaB_4 and maintaining the solution so obtained at a temperature between 950 and 1300° C. (1740 and 2370° F.).

(767) U. S. 2,482,127 (1949). A. W. Schlechten, W. J. Kroll, and L. A. Yerkes, *Apparatus for Refining Metals.* Describes an apparatus for recovering Zr from a reaction mixture of $ZrCl_4$ and Mg vapor.

ii. Precious and Rare Metals (Platinum, Rhodium, Osmium, Iridium, Gold, Silver)

(768) U. S. 159,647 (1875). W. Daehne, *Extracting Gold.* Au is precipitated in form of brown powder; the ore is treated with aqueous chloride of lime and HCl, and H_2SO_3 is used as precipitant.

(769) U. S. 205,187 (1878). F. Gutzkow, *Process of Refining Retorted Silver Amalgam.* Ag is precipitated from amalgam of Ag and Cu in H_2SO_4 by action of the Cu.

(770) U. S. 267,723 (1882). A. Schaeffer, *Process for Extracting Gold.* Au-containing ore is subjected to action of Br; Au then is separated from the Br-solution by oxalic acid or $FeSO_4$ as precipitant.

(771) U. S. 490,659 (1893). W. B. Jackson, *Process for Treating Precious Metal Ores.* Pure fine powdered Au or Ag is produced by chlorinating the ore, dissolving it in hyposulfite solution, and electrolytically treating the solution in presence of Zn plates.

(772) U. S. 513,174 (1894). C. Carter, *Apparatus for Precipitating Gold and Silver.* Apparatus precipitates Au and Ag from a cyanide solution by Zn balls which are continuously agitated to remove deposited Au from them.

(773) U. S. 521,899 (1894). J. W. Sutton, *Process for Separating Gold.* In separation of Au as powder from its chloride solution the solution is mixed with a hydrocarbon liquid which entrains the precipitated Au powder.

(774) U. S. 597,113 (1898). C. E. Greene (Gold Magnet & Mining Co.), *Composition of Matter for Gold-Collecting Plates.* Plate for collecting Au dust and powder are made from auriferous sand, made of Zn, Hg and metallic Na.

(775) U. S. 624,040 (1899). C. B. Jacobs, (Ampere Electro-Chemical Co.), *Process for Reducing Precious Metals.* Ag or Au are precipitated in metallic form from chloride or cyanide solutions by phosphide of hydrogen.

(776) U. S. 629,905 (1899). J. J. Hood, *Process for Extracting Gold.* A Zn-Sb-Hg alloy, granulated by pouring into water, is used for precipitation of Au.

(777) U. S. 630,951 (1899). L. Vanino, *Wet Process of Extracting Silver.* Pure Ag is extracted from halide salts by mixture of salts with watery solution of alkaline agents and addition of formic aldehyde.

(778) U. S. 635,793 (1899). W. M. Martino and F. Stubbs, *Process for Treating Gold Ores.* Au is obtained from a combination with metalloids by adding CaC_2 to dry, finely divided ore; on addition of water, free Au and acetylene hydrides of metalloids are produced.

(779) **U. S. 637,140** (1899). W. M. Martino and F. Stubbs, *Process for Treating Gold Ores.* Au is precipitated from an aqueous chloride or bromide solution by adding metallic carbide thereto to form hydrocarbon gases.

(780) **U. S. 729,760** (1903). G. V. Guzman, *Process for Reducing Silver.* Finely divided Ag is precipitated from solutions with cupric chloride and cuprous chloride, using granulated Cu as precipitant.

(781) **U. S. 1,090,661** (1914). G. H. Urquhart, *Process of Precipitating Precious Metals.* Au and Ag are precipitated from cyanide solutions on granulated Zn. The mass is agitated to free Au from Zn and further subdivide Zn for reuse.

(782) **U. S. 1,222,789** (1917). J. H. Niemann, *Treatment of Refractory Auriferous Ores.* Au and Se are separated by electrolytic precipitation from ore containing these elements and retorted to recover Au bullion in finely powdered form.

(783) **U. S. 1,281,249** (1918). T. B. Crowe (The Merrill Co.), *Process for Precipitating Gold from Solution.* Process and apparatus exclude oxidizing gases during precipitation of Au from cyanide solutions by replacement.

(784) **U. S. 1,323,588** (1919). A. Gordon, *Precipitation of Gold from Solution.* Au powder is precipitated from cyanide solution by using an Al plate dipped in $HgCl_2$ as precipitant.

(785) **U. S. 1,397,684** (1921). A. W. Hahn, *Cyanide Process for Silver Preparation.* In precipitation of Ag by addition of Zn dust to silver-cyanide solution, a doping solution with NaOH is found to conserve the cyanide.

(786) **U. S. 1,403,463** (1922). J. Allingham, *Process for Recovering Precious Metals, Such as Silver.* Ag is precipitated chemically, and in metallic form by a process which first subjects pregnant electrolyte to electric current to cause precipitation of unwanted metals as hydroxides.

(787) **U. S. 1,448,475** (1923). L. Weisberg, *Recovery of Silver Used for Photographic Work.* Ag is precipitated from photographic solutions by adding sugar and alkali as precipitants.

(788) **U. S. 1,527,942** (1925). L. Weisberg, *Recovery of Silver from Solution.* Ag is precipitated from photographic solutions by ferrous hydroxide in presence of an alkali.

(789) **U. S. 1,617,353** (1927). W. O. Snelling, *Extraction of Gold.* Powdered Te, prepared by precipitation or grinding, is used as a precipitant for Au and is separated therefrom by volatilization of Te.

(790) **U. S. 1,624,172** (1927). G. I. Levy (Hollywood Chemical Co.), *Process of Recovering Silver from Solution.* Metallic Ag as dark black crystals is precipitated from waste hypo-solutions by adding Zn-hydrosulfite thereto.

(791) **U. S. 1,649,786** (1927). D. C. Smith, *Process for Recovering of Platinum.* Pt is recovered from a catalytic mass by dissolving mass in HCl and reacting with Zn.

(792) **U. S. 1,687,056** (1928). R. Carl, *Process of Separating Alloys of Silver.* Ag is recovered in finely distributed form not adhering to the cathode, from its alloy with other precious and base metals.

(793) **U. S. 1,876,943** (1932). A. J. Hull (Wyoming Platinum & Gold Mining Syndicate), *Method of Recovering Platinum.* Pt sponge black powder is precipitated from a solution of chloride salts of Pt by Zn.

(794) **U. S. 2,042,121** (1936). H. C. Parker (J. W. Chard), *Process of Extracting Gold from Solution.* Au is precipitated from saline solution by powdered Ni to which Au powder adheres.

(795) **U. S. 2,204,898** (1940). H. E. Lee and B. H. Muir (Bunker Hill & Sullivan Mining Co.), *Process for Precipitating Silver from Solution.* Precipitated Ag is easily separated from continuously agitated precipitant in form of blocks, rod or balls.

(796) **U. S. 2,214,765** (1940). C. Holzwarth (Du Pont Film Manufacturing Corp.), *Process for Recovering Silver.* For precipitating Ag from photo processing bath a metal higher in the electromotive series than Ag is finely divided and dispersed in an organic colloid such as gelatin.

(797) U. S. 2,292,207 (1942). M. Dearing (Eastman Kodak Co.), *Recovery of Silver.* Ag powder is precipitated from acid-oxidizing photo-solutions by Fe or steel having a certain C and Si content and a grain size smaller than that of gray cast Fe.

(798) Brit. 572,578 (1945). A. C. Fourie, *Extracting Gold.* Pulverized ore of Au is treated with cyanide solution. After dissolution, the Au, Hg and cyanide solution are passed through tanks in contact with Cu plates which are periodically lifted, for removing Hg by heat-treatment.

(799) Brit. 594,339 (1947). Permutit Co. Ltd., *Recovery of Precious Metals.* Precious metals are recovered from solutions by passing the solution through a bed, composed of an organic, resinous, anion-absorbing material. The process is applicable to the separation of Au or Pt from spent plating liquors, provided that the metals occur as complex anions with Cl or CN.

(800) U. S. 2,454,336 (1948). A. F. B. Norwood, *Treatment of Gold or Silver Bearing Ores.* Process comprises roasting the charge of the finely divided ore with a carbonaceous material, S and common salt, extracting the Au or Ag with cyanide, and forming the residues into a charge similar to the first charge.

(801) Brit. 623,147 (1949). E. C. Herkenhoff and N. Hedley (American Cyanamid Co.), *Gold Recovery.* Slimy Au ores are treated with CaCN, then with a mixture of 55% C, 33% magnetite and 12% Na-silicate as binder. Au is adsorbed on C, and the mixture is passed through a magnetic separator for recovery of the metal.

(802) Brit. Appl. 5216/49 (1949). The Merrill Co., *Recovery of Precious Metal Values.* Describes an improved cyaniding process in which Au or Ag are recovered with ion-exchange resins, thus eliminating the precipitation process.

(803) U. S. 2,477,469 (1949). J. V. Thompson (The Dorr Co.), *Arsenical Gold Ore Treatment.* The process is carried out by adding an alkaline reagent such as lime to a mixture of ground ore and water to render arsenical constituents of the ore selectively into solution phase while minimizing precipitation. The As-solution phase is washed from the ore and the ore is cyanided to render Au into solution phase. The metal is then won by precipitation.

(804) U. S. 2,488,398 (1949). E. C. Handwerk and G. T. Mahler (The New Jersey Zinc Co.), *Basic Lead Sulfate.* Basic lead sulfate is produced from argentiferous galena and the like with subsequent recovery of Ag and Au.

iii. Ferrous Metals

(805) U. S. 74,791 (1868). G. Bischof, *Preparing of Finely Divided Iron.* Fe-oxide is heated with pulverized coal or coke, and Cu and Ag separated by precipitation of Cu in solution.

(806) U. S. 121,872 (1871). T. Hinde, *Furnace for Iron and Steel.* Crushed ore is subjected to processes of calcining, reducing and carbonizing.

(807) U. S. 115,243 (1871). E. L. Seymour, *Preparing of Iron Ores.* Granulated Fe ore is heated and mixed with pulverized C; metallized Fe then is separated by a magnetic ore separator.

(808) U. S. 183,691 (1876). W. A. Lyttle, *Manufacture of Iron and Steel from Ores.* Bricks of ore are subjected to action of hot gases, free from O.

(809) U. S. 268,840 (1882). E. Tourangin, *Process for Reduction of Iron Ores.* Sponge Fe is produced by passing carbonic oxide through mass of unheated ore.

(810) U. S. 727,118 (1903). T. A. Edison, (Edison Storage Battery Co.), *Process of Making Electrolytically Active Finely Divided Iron.* Fe compound is reduced by H_2 in presence of heat and then flooded with water to prevent oxidation.

(811) U. S. 861,593 (1907). C. G. P. DeLaval, *Extracting Iron From Its Ores.* Method comprises introducing a pulverous charge containing Fe-ore into the

rotating body of an air current mixed with C sufficient to form CO and moving in an opposite radial direction to the charge.

(812) German 249,031 (1912). S. E. Sieurin, *Reduction of Iron Ore.* Fe ore is laid down in layers with coal and lime in the furnace, then reduced under exclusion of air and without melting, whereupon the lumps of metal are separated from the slag.

(813) U. S. 1,275,232 (1918). T. A. Edison (Edison Storage Battery Co.), *Production of Finely Divided Iron.* Same as U. S. 727,118 (No. 810) except Ni is used to replace H_2 before exposing to air.

(814) U. S. 1,287,221 (1918). G. C. Carson, *Manufacture of Iron.* C freed from natural gas or petroleum is mixed and heated with Fe ore to deoxidize it.

(815) German 316,748 (1919). Allgemeine Elektrizitäts-Gesellschaft, *Iron Powder.* Fe-powder is produced by electrolyzing a bath containing 3 parts $FeCl_2$ and 4 parts NH_4Cl in 100 parts water and using Fe electrodes.

(816) U. S. 1,453,057 (1923). J. A. Williams, *Process of Making Iron and Steel.* Fe and steel are produced by reducing Fe_3O_4 to powder.

(817) Brit. 269,677 (1927). I. G. Farbenindustrie A. G., *Powdered Iron from Carbonyl.* Decomposition of $Fe(CO)_5$ is accomplished by introducing it in the liquid state into a heated vessel at considerable distance from the hot walls, so that the decomposition takes place in the hot free space.

(818) Brit. 306,215 (1929). I. G. Farbenindustrie A. G., *Iron-Powder.* Process for manufacturing pure Fe powder comprises treating the powder at 500° C. (930° F.) with a reducing gas free from C, then heating to a temperature below the melting point.

(819) Brit. 322,039 (1929). I. G. Farbenindustrie A. G., *Ferrous Metal Powder.* Production of powdered carbonyl Fe is followed by heavy comminution of the deposit.

(820) French 659,796 (1929). I. G. Farbenindustrie A. G., *Iron Powder. Cf:* Br. 306,215 (No. 818).

(821) German 478,563 (1929). Höganäs-Billesholm Aktiebolag, *Production of Sponge Iron.* The C content for the reduction is selected so that when the reduction is finished some C remains in the slag, to accelerate the cooling of the sponge and to hinder a decomposition of sulfides.

(822) German 485,639 (1929). I. G. Farbenindustrie A. G., *Production of Iron from Iron Carbonyl.* The gases carrying the Fe carbonyl stream pass through masses of small metal fragments or through liquid metal to undergo thermal decomposition.

(823) U. S. 1,735,402 (1929). O. Kramer, W. Meiser and W. Schubardt (I. G. Farbenindustrie A. G.), *Pure Iron of Small Grain Size. Cf.:* German 528,463 (No. 834).

(824) French 682,160 (1930). I. G. Farbenindustrie A. G., *Iron Powder.* Fe powder produced from the decomposition of $Fe(CO)_5$ is wetted with water to produce a film of oxide; then it is heated to 850° C. (1560° F.) to drive off CO.

(825) French 686,689 (1930). Hartstoff-Metall A. G., *Iron Powder.* Method comprises conversion of the metal to pieces of small dimensions in a ball-mill under oxidizing atmosphere and submitting to mechanical treatment.

(826) French 691,557 (1930). L. Brandt (Vereinigte Stahlwerke A. G.), *Decomposing Iron Carbonyl. Cf.:* German 555,169 (No. 837).

(827) German 493,874 (1930). I. G. Farbenindustrie A. G., *Production of Iron from Iron Carbonyl.* The undiluted $Fe(CO)_5$ in form of a liquid or vapor is contacted with a metallic melt.

(828) German 500,692 (1930). I. G. Farbenindustrie A. G., *Production of Pure Iron.* Improvement of German 485,639 (No. 822) by introducing the $Fe(CO)_5$ into the vessel so that the decomposition takes place mostly in the free space and not on the walls.

(829) U. S. 1,759,173 (1930). W. H. Smith, *Method of and Apparatus for Reducing Metallic Ferrous Oxides Without Melting.* Reduction of Fe ores without melting

is accomplished by moving the ore and a reducing agent downward through a preheating, a reducing and a cooling zone.

(830) U. S. 1,759,658 (1930). A. Mittasch and C. Müller (I. G. Farbenindustrie), *Manufacture of Pure Iron.* Pure Fe is produced by subjecting Fe carbonyl vapor in diluted condition to thermal decomposition by contacting it with molten Fe.

(831) U. S. 1,759,659 (1930). A. Mittasch, C. Müller and W. Schubardt (I. G. Farbenindustrie), *Manufacture of Pure Iron from Iron Carbonyl.* Fe carbonyl is decomposed in the hot free space of a heated vessel substantially at a distance from their hot walls.

(832) U. S. 1,759,660 (1930). A. Mittasch (I. G. Farbenindustrie A. G.), *Production of Pure Iron.* Liquid Fe carbonyl drops into paraffin oil heated to 270° C. (520° F.), so that the resulting Fe remains suspended as a fine powder.

(833) German 526,581 (1931). I. G. Farbenindustrie A. G., *Iron Powder.* Fe powder produced from Fe carbonyl with 0.98% C is heated in H_2 at 900° C. (1650° F.) while the C content is decreased by 0.03%.

(834) German 528,463 (1931). I. G. Farbenindustrie A. G., *Pure Iron of Small Grain Size.* Fe powder is treated with a C-free reducing gas at 300-500° C. (570-930° F.), then heated in an inert atmosphere above 500° C. (930° F.), then pulverized.

(835) U. S. 1,819,164 (1931). H. L. Hartenstein, *Method of Producing Pyrophoric Iron.* Fe ore mixed with peat is reduced by H_2 and cooled in absence of air.

(836) Brit. 374,560 (1932). I. G. Farbenindustrie A. G., *Production of Metals.* Method comprises heating Fe in a state permeable to gases with a chloride of a heavy metal, having a specific gravity of 4.5, a potential below 0.79 volt, to 900° C. (1650° F.), while preventing a free access of oxidizing gases.

(837) German 555,169 (1932). Vereinigte Stahlwerke A. F. and L. Brandt, *Iron Powder by Decomposing Iron Carbonyl.* The decomposition for the production of powdered Fe takes place on particles of quartz or glass.

(838) German 565,737 (1932). A. Musso, *Apparatus for the Reduction of Powdered Iron.* A revolving type furnace for the reduction of powdered Fe is uniformly heated, and the Fe ore runs uniformly through the compartments of the rotating drum.

(839) German 568,877 (1932). I. G. Farbenindustrie A. G. and L. Schlecht and F. Duftschmid, *Powdered Iron.* Fe treated with NH_3 becomes brittle and can be comminuted easily.

(840) U. S. 1,846,530 (1932). W. H. Smith (General Reduction Corp.), *Process of Reducing Iron Ore Without Melting.* Reduction of Fe ore to sponge Fe is accomplished by maintaining three distinct, positive and separate zones to control the separate successive reduction steps.

(841) U. S. 1,928,140 (1933). W. H. Smith (General Reduction Corp.), *Method of Reducing Metallic Oxides of Iron.* Reduction of Fe ore without melting is accomplished by close control of temperature.

(842) Brit. 421,566 (1934). C. J. Head, *Sponge Iron.* Preparation of Fe sponge i is claimed by a special method employing CaO, Fe-oxide, scrap Fe and carbonaceous matter.

(843) U. S. 1,964,402 (1934). B.M.S. Kalling and C. von Delwig (A. Johnson & Co.), *Method of Reducing Iron Ore.* A reducing agent is added to a mixture of Fe ore and solid carbonaceous material in a rotating heat zone.

(844) U. S. S. R. 42,112 (1935). S. L. Yuz'ko, *Method of Making Sponge Iron From Pyrite.* Pyrite is oxidized in the upper part of a kiln and the powder is reduced in the lower section with CO and CH_4, obtained from blast furnace gases after removal of S and dust.

(845) Brit. 441,429 (1936). A. G. Wintershall, *Reduction of Iron Ore Powder.* Fe ore powder is reduced in rotating furnaces at 750-900° C. (1380-1650° F.) in the presence of a mixture of carbonic acid and H.

(846) U. S. 2,028,105 (1936). C. J. Head, *Sponge Iron. Cf.:* Brit. 421,566 (No. 842).

(847) U. S. 2,065,618 (1936). C. F. Sherwood (J.A. Dienner and Hansen Rubber Products Co.), *Ferrous Metal and Method of Producing Same.* Pure Fe of an open porous structure is formed by dividing oxide of Fe into relatively fine particles, adding slight amount of C, mixing with binder, briquetting and forming mixture in presence of a reducing agent.

(848) French 821,115 (1937). F. L. Duffield, *Manufacture of Iron by Dividing Iron Ore.* Method comprises reduction of divided Fe ore by mixing it with C, shaping mixture into blocks, and passing the blocks through the reduction furnace.

(849) U. S. 2,076,909 (1937). B. Miller and C. G. Fink (Patents Corp. of America), *Electrolytic Iron Manufacture.* Fe is deposited on a rotary cathode surrounded by a Fe-anode submerged in a $FeCl_2$ electrolyte containing NaF.

(850) U. S. 2,096,009 (1937). A. Schmid (O. F. Wyss), *Method for Making Semi-Pyrophoric Iron.* Fe compounds are reduced by H_2 at a specific temperature.

(851) U. S. 2,103,131 (1937). H. C. Wolf (Irsugo Consolidated Mines Ltd.), *Method of Unlocking Ore Bodies to Extract Sulphur and Win Iron.* Ore is pulverized to pass through a 200 mesh screen, heated in a retort to 315-485° C. (600-900° F.) to vaporize S. Material in the retort is kept in constant agitation, vapor is drawn off, and Fe residue is dried.

(852) German 665,100 (1938). K. Mitterbiller-Epp and W. Fruehwein, *Production of Iron Powder.* Method of producing Fe from ores comprises mixing the ores with C and $FeCl_3$, heating the mixture to red heat for reaction, and further heating to 700° C. (1290° F.) to separate the Fe in crystalline form.

(853) U. S. 2,107,549 (1938). H. Schmalfeldt, *Process of Reduction of Fine Iron Ores.* Production of Fe powder in a rotary reduction drum comprises bringing Fe-ores into contact with CO and introducing pure O in drum to form CO_2.

(854) U. S. 2,135,466 (1938). K. Iwase, *Treatment of Titanium-Bearing Ores or Sponge Iron Produced from Them.* Process of separating TiO_2 and SiO_2 from spongy Fe comprises heating the ore in an electrical furnace together with MnO_2 and CaO to fuse the SiO_2 with the TiO_2 and to form a eutectic mixture, freeing the Fe.

(855) Brit. 503,306 (1939). Deutsche Gold- & Silberscheideanstalt, *Iron Powder of Great Reactivity.* $FeCl_2$ solution containing ammonium salts is electrolyzed in the presence of organic acids; the resulting cathode product is reduced to the desired fineness.

(856) Brit. 507,277 (1939). Deutsche Gold- & Silberscheideanstalt, *Production of Iron Powder.* Fe oxide is moistened with water in presence of small quantity of $FeCl_3$, then heated to 100-200° C. (210-390° F.). Product obtained is reduced by H_2 at 500-600° (930-1110° F.).

(857) Brit. 507,431; 507,432; 507,494; 507,581 (1939). H. Gallusser, *Methods and Furnaces for Extracting Iron.* Method comprises filling metal oxides plus reducing agent into a metallic horizontal rotary drum, the wall of which forms the secondary winding of a transformer with a closed Fe path. After partly filling and closing the drum, it is heated by induced currents, rotated, and H_2 introduced through the shaft of the rotary drum.

(858) German 673,941 (1939). Klöckner Werke A. G., *Sponge Iron.* Production of sponge Fe from purple ore containing Zn, which is mixed with 30% of fuel, comprises heating the mixture in a muffel or retort to 1250° C. (2280° F.) till the Fe oxide is reduced, at which temperature the vapors of Zn and S are driven off.

(859) German 680,605 (1939). H. Koppers G.m.b.H., *Sponge Iron.* Layout for producing sponge iron employs reducing gases generated from lignite. The ore used for this purpose is not suitable for smelting.

(860) U. S. 2,142,100 (1939). J. M. Avery, *Sponge Iron.* Manufacture by gaseous reduction provides for circulating gas back to the reduction zone after purification.

(861) U. S. 2,146,625 (1939). B. Christiansen, *Reducing Ferrous Metal Oxides.* Method comprises heating briquettes of a mixture of Fe oxide powder and C to a sintering temperature for the reduced metal in a channel furnace by burning gas in the chamber.

(862) U. S. 2,156,263 (1939). K. Kasuka and H. Ashida, *Sponge Iron by Direct Reduction.* Material to be reduced passes through reaction tube, which has a

heating wire on its periphery, while being subjected to a reducing gas stream.

(863) U. S. 2,157,699 (1939). C. Hardy and C. L. Mantell, (Hardy Metallurgical Corp.), *Electrolytic Iron Powder Production.* Electrolytic production of Fe powder comprises introducing Fe-bearing material into the electrolytic cell with a Zn cathode and an aqueous electrolyte containing $FeSO_4$ and sugar or glycerine.

(864) U. S. 2,157,934 (1939). C. Hardy and C. L. Mantell (Hardy Metallurgical Corp.), *Electrolytic Iron Powder.* Preparation of Fe-powder is accomplished in an electrolytic cell from $FeSO_4$ solution.

(865) U. S. 2,164,198 (1939). F. O. Clements, R. H. Terry and D. J. Henry (General Motors Corp.), *Powdered Iron.* Process consists of carburizing Fe, rapidly cooling, breaking it into particles of desired size, and annealing them in reducing atmosphere, to make them soft and briquettable, and reduce oxidation.

(866) U. S. 2,166,207 (1939). W. G. Clark (Clarkiron Inc.), *Reducing Iron Oxide Ores.* Method comprises moving Fe oxide ores in granular form downward through a heating and reducing zone, while increasing the temperature to 950° C. (1740° F.), and discharging Fe in a cooling zone.

(867) U. S. 2,168,597 (1939). A. Aurial and A. Aurial, *Direct Production of Steel and Other Metals from Ore.* Method comprises reducing finely divided mineral material by preheating the mineral in upward directed streams of gases within a chamber, and simultaneously dropping the minerals through the gases into a reduction zone with a deoxidizing atmosphere; products are fused on the bottom of the reducing zone.

(868) U. S. 2,170,158 (1939). I. Rennerfelt, *Method of Decarburizing a Carbon-Holding Metal, For Instance Pig Iron.* Production of low-C Fe-grains comprises granulating Fe by rapid cooling, classifying granules according to their size, and then heating in rotating tubular furnace a graduated class of granules for decarbonizing in gases containing CO and CO_2.

(869) Brit. 527,430 (1940). Association Des Ouvriers En Instruments de Précision. *Iron in Powdered Form.* Scrap is subjected to oxidation, pulverized, then reduced.

(870) Canadian 436,699 (1940). F. A. Fahrenwald, *Sponge Metal Production.* Fe sulphide ores are chlorinated for manufacture of sponge Fe; $FeCl_3$ is oxidized, and product is reduced.

(871) French 856,330 (1940). Soc. Métaux Pulvérulents, *Production of Pure Iron Powder.* Thin Fe wires are treated with steam for the transformation into Fe_3O_4, followed by crushing, pulverizing and reducing by heated H_2.

(872) German 687,529 (1940). Deutsche Gold- & Silberscheideanstalt A. G. and C. Bauer, *Production of Iron Powder.* The electrolysis of a solution of $FeCl_2$ and NH_4Cl occurs in the presence of formic acid at elevated temperature.

(873) Swedish 99,541 (1940). I. Rennerfelt, *Iron with Low Carbon-Content.* Powdered Fe ore is mixed with granular Fe and subjected to heat treatment below smelting temperature. Product obtained is in granular form.

(874) Swiss 208,188 (1940). Deutsche Gold- & Silberscheideanstalt A. G., *Production of Iron Powder.* Fe powder is heated in the presence of Fe halides (*e.g.*, Fe bromides) and air; the oxidized product is then reduced with H_2 at 500-600° C. (930-1110° F.).

(875) U. S. 2,207,879 (1940). A. Schmid (O. F. Wyss), *Method for Making Semi-Pyrophoric Iron.* Fe oxalate is heated in presence of inert gases.

(876) U. S. 2,217,569 (1940). W. Stephan (Chemical Marketing Co., Inc.), *Process for the Production of Metallic Iron Powder.* Fe powder of great fineness is produced by moistening it with water in the presence of a small quantity of Fe-halides and subjecting the moistened powder to air at a temperature at which the water evaporates.

(877) German 716,025 (1941). Fried. Krupp-Grusonwerk A. G., *Reducing Iron Ore.* Reduction occurs in a rotary kiln, and the formed sponge Fe is subsequently made into a bloom.

(878) U. S. 2,266,816 (1941). S. Ruzicka, *Manufacture of High-Grade Iron and Steel.* Oxide-ores are mixed with solid carbonaceous fuel and with aluminous and calcareous slag-forming ingredients to produce a quick setting alumina cement by passing the mixture through a rotary kiln to cause reduction of ore to sponge metal.

(879) U. S. S. R. 59,805 (1941). M. Yu. Bal'shin and V. P. Makhaev, *Porous Iron Mass.* An inorganic acid and water are added to powdered Fe ore or its calcination product, and the powdery mass is reduced, impregnated with bitumen and briquetted.

(880) Brit. 545,057 (1942). E. Mehl, *Powdered Iron.* An aqueous solution of caustic alkali or a mixture of caustic alkali with a specific gravity of 1.35 and 1.60 is electrolyzed at a temperature exceeding 100° C. (210° F.) with the aid of anodes of a ferrous material for a time sufficient to build up a spongy Fe deposit on the cathode which is detached and collected.

(881) French 871,323 (1942). H. Vogt, *Production of Iron Powder.* Fe powder for metallo-ceramic purposes is produced from hammer scale or mill scale, which is cleaned, crushed, and reduced and cooled in CO.

(882) Italian 396,515 (1942). E. C. Holtz and A. D'Exarque, *Process for Obtaining Extremely Pure Iron from Iron Carbonyls Through Thermal Decomposition.* A very fine, spherical Fe powder is obtained by decomposing an Fe carbonyl within a closed chamber holding a certain gas atmosphere, at a certain temperature and pressure.

(883) U. S. 2,277,067 (1942). H. A. Brassert (Minerals & Metals Corp.), *Manufacture of Ferrous Metal Products.* Method comprises producing metallic bodies directly from powdered Fe ore without melting.

(884) U. S. 2,282,124; 2,282,144 (1942). F. A. Fahrenwald, *Production of Iron from Iron-Oxide.* Sponge Fe of high purity is obtained by heating mill scale in contact with oxidizing gases and later deoxidizing.

(885) U. S. 2,287,082 (1942). K. Bauer (Chemical Marketing Co.), *Iron Powder.* Fe powder of great reactivity and readily soluble in diluted acids is produced by electrolyzing $FeCl_2$ solution containing NH_4Cl in presence of formic acid.

(886) U. S. 2,287,663 (1942). H. A. Brassert (Minerals & Metals Corp.), *Metals such as Iron and Steel.* Method of production comprises reducing finely concentrated Fe ore at temperatures below the melting and sintering point of the metal to be recovered, and pressing the resulting powder into a compact mass while still hot.

(887) U. S. 2,288,613 (1942). G. D. Dill (Minerals & Metals Corp.), *Reduction of Metallic Oxides such as those of Iron.* Method comprises reduction of metallic Fe oxides capable of effecting catalytic decompositions and/or cracking of hydrocarbons under certain temperature conditions by entraining the oxide in a stream of hydrocarbon.

(888) U. S. 2,293,939 (1942). F. A. Fahrenwald, *Amelioration of Iron.* SiO_2-free Fe powder is produced by passing gaseous HF over Fe oxide ore in the entrance zone of the furnace before reduction.

(889) U. S. 2,296,498 (1942). H. A. Brassert (Minerals & Metals Corp.), *Production of Metals Directly from Ore.* Fe ore is ground, the gangue removed by magnetic separation, fluxes and alloying metals are added, and a reducing gas is passed through the mass, while it is heated without fusion, followed by discharging the reduced ore through the grain-consolidating temperature, and pressing the grains together.

(890) Brit. 557,868 (1943). Minerals & Metals Corp. and A. H. Stevens, *Production and Consolidation of Ferrous Metals and Alloys.* Process comprises direct reduction of finely divided concentrated Fe ore. Metallic powder is compressed in protective atmosphere while still hot from the reducing operation.

(891) Swedish 109,633 (1943). A. B. Hamax, *Method for Producing Metallic Iron from Iron Oxide Material.* The crushed Fe oxide material is oxidized in the presence of an agent having a stronger oxidizing power than air so that the bonds between the Fe oxide compounds and the gangue are in part, or entirely eliminated; while the ore is being smelted, the material thus oxidized is reduced by the use of

a C-rich or C-free reducing agent and the Fe obtained is separated in powdered form from the rest of the material.

(892) U. S. 2,311,962 (1943). C. Payne, *Apparatus for Low Temperature Reduction of Iron Ores.* Method comprises reducing preheated Fe ore concentrates with preheated reducing gas.

(893) U. S. 2,323,305 (1943). D. Burruss and J. E. Drapeau (Glidden Co.), *Reduction Apparatus.* Method comprises producing high-purity Fe powders from Fe oxides by continuous process in a reducing furnace.

(894) U. S. 2,333,111 (1943). H. G. Lykken, *Apparatus for Processing Iron Ores.* Apparatus and method for producing Fe powder by reducing finely divided ores are claimed.

(895) French 900,422 (1944). Mannesmannröhren-Werke, *Iron Powder.* Process comprises air atomizing of molten cast iron containing small percentage of Si. The powder is then decarburized with 15% Fe-oxide in a container at 900° C. (1650° F.).

(896) German 744,820 (1944). Metallgesellschaft A. G., Deutsche Pulvermetallurgische Gesellschaft, and W. Siecke, *Powdered Iron of Predetermined Porosity.* High-grade Fe ore is reduced, the desired porosity of the mass is obtained by mechanical impact, and the product is completely reduced to metallic Fe.

(897) U. S. 2,365,194 (1944). F. Hodson (American Ore Reduction Company), *Method for Reducing Iron Ores.* Reducing Fe ores in finely divided state in carbonaceous gaseous atmosphere is claimed.

(898) Brit. 569,011 (1945). P. Hancock (Birmingham Electric Furnaces Ltd.), *Iron Powder.* Fe-oxide powder mixed with powdered C and H_2O, to form a slurry, is heated at 650–1150° C. (1200–2100° F.) in a furnace in a gaseous atmosphere of partially burned gas which reduces any excess of oxide in the mixture.

(899) Brit. 571,442 (1945). Hurst, Bradley & Foster and P. F. Hancock, *Iron Powder.* Fe powder is made by heating an intimate mixture of cast Fe in finely divided form and an oxide of Fe at temperatures between 750 and 1100° C. (1380 and 2010° F.).

(900) Brit. 573,593 (1945). Standard Oil Development Co., *Recovery of Metals from Ores.* Fe ore is suspended in a vertically rising reducing gas, rich in free H, in a zone maintained at the reduction temperature but below that at which the metal becomes plastic.

(901) Canadian 441,772 (1945). J. E. Silvasy and L. Taylor, *Ferrous Metal Powder.* Fe powder is made in a continuous process by reducing pulverized ore with hydrocarbon gases in an externally heated retort.

(902) U. S. 2,366,298 (1945). S. F. Urban, *Extracting of Iron from Pickle Liquor.* Method comprises recovering Fe powder from spent pickle liquors by electrolysis, using a Hg cathode, the Hg being distilled off, leaving powdered Fe.

(903) U. S. 2,366,371 (1945). N. K. G. Tholand, *Powder Metallurgy.* Producing powdered metal by subdividing a C-containing ferrous metal in the liquid state, solidifying and then mechanically disintegrating it to a particle size not greater than 40 mesh and decarburizing.

(904) U. S. 2,368,489 (1945). R. L. Patterson, *Production of Metal Powder.* Production of Fe powder is accomplished by gaseous reduction in a plurality of stages of different temperatures.

(905) U. S. 2,377,486 (1945). J. V. Fill (Micro Products Corp.), *Carbonyl Iron.* By thermal decomposition of $Fe(CO)_5$ under conditions of increasing the volume and decreasing the concentration and pressure, by moving the gas downward in a heated chamber whose walls diverge, iron powder is formed.

(906) U. S. 2,377,676 (1945). C. D. Coxe (Remington Arms Co., Inc.), *Preparation of Powdered Ferrous Metals.* Process comprises dissolving Fe_2O_3 in molten borax, adding NaCN to the melt below the sintering point of Fe to precipitate finely divided metal, and leaching the extraneous material from the resulting Fe.

(907) U. S. 2,380,406 (1945). R. C. Buehl (United States Government), *Production of Low-Sulphur Sponge Iron.* A metallurgical composition is claimed for the production of a relatively S-free metal which comprises an Fe ore and a calcined mixture of coking coal with limestone.

(908) U. S. 2,381,440 (1945). J. E. Drapeau (Glidden Co.), *High-Density Compressible Iron Powder and Process.* Fe powder, composed of particles of micro-crystalline structure and having thin, porous spongy surfaces of substantially uniform thickness, is produced by a special reduction process.

(909) U. S. 2,386,072 (1945). E. A. Stewart, *Method of Making Sponge Iron.* Process of reducing Fe oxide with carbonaceous matter comprises forming a hollow block consisting of the oxide and a binder, filling the interior and surrounding the exterior with carbonaceous material, and subjecting the whole to heat to generate reducing gases.

(910) U. S. 2,386,073 (1945). J. H. Stewart, *Reducing Iron Oxides.* Sponge Fe is made by forming blocks of finely divided Fe oxides with starch solutions as a binder, placing them in a container of special composition and heating at 1100° C. (2000° F.) for 4-5 hours.

(911) U. S. 2,389,734 (1945). E. Mehl, *Process for the Production of Iron Powder.* Electrolytic process for the production of Fe deposits comprises electrolyzing, an aqueous solution of caustic alkali with a Fe anode and a cathode inert to the electrolyte.

(912) French 913,502 (1946). H. Freeman, *Iron Powder.* The impurities in shotted or atomized cast Fe are fluxed out by mixing the powder with Na_2CO_3, heating to 1000° C. (1830° F.), and tumbling the product in water.

(913) French 914,464 (1946). Imperial Chemical Industries Ltd., *Iron Powder.* Pure Fe powder is made from oxide containing 1% Si, such as millscale, by (*1*) treating with a slow stream of dry H_2 containing 1-3% HF; or (*2*) by mixing millscale with Fe-fluoride, and passing through it dry H_2.

(914) French 918,458 (1946). Butler Brothers, Inc., *Electrolytic Iron Powder.* A dull deposit is formed on stainless steel cathodes from $FeCl_2$ solution of an Fe content of 75 mg. per liter and maintained at 25° C. (77° F.).

(915) Swedish 117,080 (1946). J.A.B. Ödberg and Stora Kopparsbergs Bergslags A. B., *Sponge Iron.* Fe-oxide is heated and reduced while passing downward through a tower, into whose bottom is introduced CO gas; CO_2 gas is withdrawn higher up in the tower, and passed over a carburator; air is introduced to burn the remaining CO and to preheat the Fe-oxide.

(916) Swedish 117,547 (1946). E. Ameen and I. Kihlander (Stora Koppersbergs B. A.), *Spongy Iron.* Fe-oxide is heated and reduced while passing downward through a shaft furnace; Co is introduced into the lower part of the furnace. Decomposition of CO takes place with precipitation of C within the sponge iron.

(917) U. S. 2,395,999 (1946). J. V. Fill (Maguire Industries), *Method for the Manufacture of Metal Carbonyls.* Continuous method for making $Fe(CO)_5$ comprises CO gas and sponge metal which are continuously fed to the reaction chamber, from which the gaseous $Fe(CO)_5$ is withdrawn and condensed; then the liquid is separated from the excess of metal, and carbonyl Fe powder is deposited.

(918) U. S. 2,399,984 (1946). L. Caldwell, *Method and Apparatus for Gaseous Reduction of Iron Oxide.* Method and apparatus for gaseous reduction of Fe oxide to form metal powder are claimed.

(919) U. S. 2,403,463 (1946). C. R. Seliger (Henry Blech), *Art of Reducing Metals.* Fe is reduced to fine particle form by melting, allowing to cool to semi-liquid consistency in the temperature range from 30 to 60° C. (50° to 100° F.) below the melting point while being puddled, maintaining Fe at that range of temperature while forcing it by impact through a heated foraminous plate, and cooling to solidification.

(920) U. S. 2,404,650 (1946). D. Newkirk (Ford Motor Co.), *Processing Kiln.* A kiln for producing powdered Fe by the reduction of Fe-oxide is claimed.

(921) U. S. 2,413,411 (1946). W. J. Kroll, *Iron Powder.* Fe powder is produced at the cathode of an electrolytic cell in which the electrolyte is anhydrous molten $FeCl_2$ and the anode is Fe, which is consumed during the electrolysis.

(922) U. S. 2,413,492 (1946). C. V. Firth (Continental Machines Inc.), *Production of Iron Powder.* Production of Fe powder from low grade ores comprises the preparation of a crushed crude carbonate slate, which is digested with H_2SO_4, then filtered, and followed by crystallization of $FeSO_4$; Fe oxide is produced

by selective calcination, followed by its agglomeration for the reduction, after which the pure Fe powder is cooled.

(923) Brit. 592,404 (1947). Imperial Chemical Industries, Ltd., A. J. Walkley, D. E. Palin and L. J. Burrage, *Production of Powdered Iron.* Process employs the treatment of mill scale with HF.

(924) Brit. Appl. 10389/47 (1947). International Minerals & Chemical Corp., *Electrolysis of Iron Powder.* $FeCl_2$ bath is modified by adding 0.1-0.3% of a hydrophilic colloid, to make the deposits on the graphite electrodes loose and powdery for easier removing.

(925) Brit. Appl. 34519/47 (1947). D. Primavesi, *Electrolytic Deposition of Ferrous Metals.* Fe powder is produced in a NaCl–KCl bath at 750° C. (1380° F.) with the voltage being held to 2 volts by adding chlorine intermittently, to regulate the Fe-ion concentration and thereby to control the particle size. The chlorine may be passed over another metal, *e.g.* Cr, when an alloy powder is to be produced.

(926) U. S. 2,417,949 (1947). E. Riveroll, *Process for Recovery of Iron from Ore.* Process provides for recovery of Fe from certain ores whereby a hydrocarbon fluid is used as agent for the reduction without introduction of any solid reducing agent.

(927) U. S. 2,418,148 (1947). C. E. Williams and A. S. Henderson, *Crystalline Iron by Hydrogen Reduction of Ferrous-Chloride.* Method of producing crystalline Fe comprises the reduction with H_2 of $FeCl_2$ and yields Fe powder of uniform size and density.

(928) Canadian 444,960 (1947). Ferrum Ltd. and H. Freeman, *Soft Iron Powder.* Finely divided cast Fe with 3-5% C is heated with alkali metal containing an oxidizing agent, *e.g.* 30–50 parts of Na_2CO_3.

(929) Canadian 445,608; 445,609 (1947). Ferrum Ltd. and H. Freeman, *Finely Divided Iron.* Crushed oxidized Fe ore mixed with C and alkaline reagent as Na_2CO_3 or NaOH is heated to 850° C. (1560° F.) and sintered. Fe_2O_3 mixed with carbonaceous material containing volatile constituents and fixed C is charged into the hot reaction chamber.

(930) Swedish 119,817 (1947). Höganäs-Billesholm A. B. and N. H. Brundin, *Production of Iron Powder by Reduction of Vanadium-Containing Ores.* Fe ore containing V is reduced in presence of NaOH and subjected to an oxidation, to convert the lower V-oxides to V_2O_5, which combines with NaOH to form a vanadate which is removed by leaching. A spongy Fe is obtained by introducing air into the mass.

(931) U. S. 2,418,148 (1947). C. E. Williams and A. S. Henderson (Henry L. Crowley & Co. Inc.), *Producing Crystalline Iron.* $FeCl_2$ is heated to 550-650° C. (1020-1200° F.) while a flow of H_2 is maintained through it until the reduction to Fe is completed; the metal is then cooled rapidly and pulverized.

(932) Brit. 598,660 (1948). G. L. Miller (Murex Ltd.), *Production of Iron Powder.* $FeCl_2$ crystals are prepared from spent pickle liquor by crystallization above 70° C. (140° F.); after H_2-reduction at 600° C. (1110° F.), the product is wet-milled, dried and subjected to a second H_2-treatment at 850° C. (1560° F.).

(933) Brit. 601,553 (1948). Butler Brothers, Inc., *Electro Deposition of Iron.* *Cf.:* French 918,458 (No. 914).

(934) Brit. Appl. 3766/48 (1948). Mantle Lamp Co. of America, *Reduction of Oxide Powders of Iron.* A mixture of Fe oxide and charcoal is heated to 1040° C. (1900° F.) for 8 hours; the cake is milled and again heated at the same temperature for 5 hours, to reduce the oxide to less than 1%; the powder is then completely reduced by annealing in H at 845° C. (1550° F.), decreasing to 200° C. (390° F.) during 5 hours.

(935) Brit. Appl. 7940/48 (1948). National Carbon Co. Inc., *Treatment of Waste Pickle Liquor.* Continuous process for depositing pure Fe from $FeSO_4$ solution provides that the effluent is treated with NH_3 to give a pure magnetic oxide and $(NH_4)_2SO_4$.

(936) Brit. Appl. 28841/48 (1948). Minerals and Metals Corp., S.A., *Apparatus for Reducing Metallic Oxides.* A twin furnace arrangement provides for reducing wet briquettes of Fe ore to such degree that they can be transferred to another furnace for complete reduction in H_2 to pure Fe powder.

(937) Brit. Appl. 32066/48 (1948). D. Primavesi, *Depositing Electrolytic Iron Powder.* The powder is made in $FeCl_2$ bath, in which NH_4Cl should be present at 100 g./l. solution containing 50-100 g. Fe/l.

(938) Brit. Appl. 32363/48 (1948). D. Primavesi, *Process for Obtaining Powdered Metal.* Fe ore is chlorinated with recycling of the gases, resulting in high-purity powdered metal.

(939) Brit. Appl. 33170/48 (1948). D. Primavesi, *Making Powdered Metals.* A cheap Fe powder is claimed to be made by heating metal chips in a cyanide bath at 950° C. (1740° F.), quenching, grinding, reducing in H_2, and magnetically separating.

(940) Canadian 451,479 (1948). Fansteel Metallurgical Corp., *Electrolytic Production of Iron.* Fe is deposited from a solution onto a highly porous electrode of lightly sintered Fe powder; the plated cathode is then hammer-milled.

(941) Canadian 451,638; 451,639 (1948). Fansteel Metallurgical Corp., *Electrolytic Production of Iron.* An electrolyte of $FeSO_4$, NH_4Cl and $FeCl_2$, and a cathode of Mo are used; the product is comminuted and reduced in H_2, to remove all Cl.

(942) French 937,013 (1948). Husqvarna Vapentfabriks, A.B., *Manufacture of Metal Powders by Electrolysis.* Finely ground Fe ore is mixed with 20% excess graphite, and then with coal tar pitch, to form a rod which is baked. Then a a bath of 44% NaCl and 56% KCl is used, and operated at 20 amps. The yield is 92.6%, and the C-content of the powder 1.2%.

(943) Swedish 124,075 (1948). N. E. Svensson, *Reduction of Metal Oxide Powders.* Fe ores are reduced to metallic Fe powder by gases passing spirally upward through a descending stream of the oxide powder.

(944) U. S. 2,441,770 (1948). W. J. Kroll, *Process for Making Iron Powder.* Process comprises treating $FeCl_2$ with NH_3, condensing NH_4Cl apart from FeN and reacting the NH_4Cl with lime, returning the regenerated NH_3 to the first step, and then heating the FeN in H_2 to form Fe powder and NH_3.

(945) U. S. 2,444,916 (1948). A. T. Cape and C. V. Foerster (Coast Reduction Inc.), *Reduction of Iron Ores.* Method of reduction of Fe ore comprises mixing it with Na, K or Ba and water, then evaporating the water so that ore particles are covered with a layer of discrete particles of the carbonate, and subjecting the coated ore particles to a gaseous reduction.

(946) U. S. 2,445,648 (1948). E. C. Truesdale (New Jersey Zinc Co.), *Method of Producing Metal Powder.* Fe oxide is compacted to pellets with a binder and the pellets are roasted under strongly oxidizing conditions before being reduced with H_2.

(947) U. S. 2,447,426 (1948). J. A. B. Ödberg, *Production of Carbon Monoxide for Manufacture of Sponge Iron.* Process is carried out in a cupola furnace with electrodes producing two gas streams which are later mixed with another for the manufacturing of sponge Fe.

(948) Brit. Appl. 218/49 (1949). D. Primavesi, *Chemical Process for Producing Iron Powder.* A cyclic process is claimed in which $FeCl_2$ is precipitated from a solution by means of a HCl steam mixture obtained by reducing the $FeCl_2$ to oxide; the oxide is then reduced to sponge Fe.

(949) Canadian 454,776 (1949). E. A. Stewart, *Sponge Iron.* Fe oxides are reduced by forming a hollow block of finely divided oxide and 7% starch solution, filling the interior and surrounding the exterior with C and lime and heating.

(950) Canadian 454,777 (1949). J. H. Stewart, *Reduction of Iron Ore Oxides.* Process consists of forming a block of finely divided oxides and starch, forming a container for the block of C, bentonite and lime, and coating its exterior with a film of Na-silicate and clay and heating to 1090° C. (2000° F.).

(951) Canadian 463,295 (1949). J. Wulff, *Iron Powder.* A high-C ferrous melt is atomized and quenched in water after which it is stamped, ball-milled, screened and magnetically separated, yielding a Fe powder suitable for pressing and sintering.

(952) French 941,412 (1949). Pluro, Inc., *Reduction of Metal Oxides.* Fe ore of 5 microns is heated to 900-1500° C. (1650-2730° F.) and fed by gravity, assisted by a pilot jet of H_2, in a reducing chamber where it is dispersed by further jets of H_2, and then reduced. Fe powder is separated and gases are recycled.

(953) U. S. 2,464,168 (1949). C. W. Balke (Fansteel Metallurgical Corp.), *Electrolytic Iron for Powder Metallurgy Purposes.* An electrolyte for the electrodeposition of Fe for powder metallurgy purposes consists essentially of an aqueous solvent and a solute of $FeCl_2$, $(NH_4)_2SO_4$, $FeSO_4$ and a small amount of acid. The three first-mentioned ingredients are present in the ratio of about 1:7:9 to about 1:23:32.

(954) U. S. 2,464,889 (1949). R. D. Pike and J. Schoder (Tacoma Powdered Metals Co., Inc.), *Process for Making Electrolytic Iron.* Fe is recovered in a non-reguline form from scrap materials or the like by electrodepositing the Fe from an electrolyte in which Fe containing the scrap material has been leached.

(955) U. S. 2,480,156 (1949). A. E. Matson and H. V. Trask (Buel Metals Co.), *Electrodeposition of Iron.* The process produces Fe of such brittle character that it may readily be pulverized to particles of the required sizes and of such dendritic or angular structure as to cause them to intermesh with each other uniformly in the forming dies.

(956) U. S. 2,481,079 (1949). H. M. Casey (Chrysler Corp.), *Method of Making Electrolytic Dendritic Powdered Iron.* A solution of $FeCl_2$ and NH_4Cl is prepared through which a current having a density of from 45 to 200 amps. per sq. ft. is passed. The current is passed between a ferrous cathode and an anode comprising separate Fe and C portions of such relative surface areas and so spaced from the cathode that from 5 to 10% of the current is conducted directly to the solution by the C portion of the anode.

(957) U. S. 2,484,266 (1949). L. E. Bowe (Monsanto Chemical Co.), *Production of Alkali Metals from Ferrophosphorus and Alkali Carbonates or Hydroxides.* The process comprises reacting Na_2CO_3 or K_2CO_3 with ferrophosphorus in a dry inert atmosphere under reduced pressure and at 900-1500° C. (1650-2730° F.). The process makes possible the recovery of the Fe content of ferrophosphorus in the form of a powdered Fe product which is free of O and/or P.

iv. Nonferrous Metals (Copper, Nickel, Cobalt, Manganese)

(958) Brit. 2,106/1865 (1865). W. Johnson, *Copper Powder.* Production comprises electrolyzing a solution of $CuSO_4$ acidified with H_2SO_4.

(959) U. S. 60,514 (1866). W. Henderson, *Treating Ores of Copper.* Cu is precipitated from acid solution of its ore by powdered Fe.

(960) U. S. 96,525 (1869). W. Wilcox, *Process of Utilizing the Waste in Copper.* Cu is precipitated by Fe from acids solutions used in cleaning Cu and brass goods.

(961) Brit. 12,626 (1890). L. Mond, *Production of Nickel.* Method comprises extraction of Ni from substances by calcination, reduction and treatment with carbonic oxide, whereby Ni is volatilized in form of a Ni-C-O gas at low temperature; Ni is obtained from the compound by heating, depositing as a plate, scale, sponge, or powder.

(962) U. S. 455,228; 455,229 (1891). L. Mond, *Process of Obtaining Metallic Nickel.* Process of obtaining Ni from Ni ores comprises heating the ore with gaseous fuel to 400° C. (750° F.) and treating the reduced ore at 150° C. (300° F.) with carbonic oxide, to obtain a Ni-CO compound; then depositing the Ni by heating to 180° C. (356° F.), into different forms, including fine powder.

(963) U. S. 483,924 (1892). T. S. Hunt and J. Douglas, *Process of Separating Copper from Ores.* Metallic Cu is precipitated by metallic Fe or electric current from acid solution of Cu, Ni and Fe.

(964) U. S. 563,144 (1896). J. Douglas, *Process for Extracting Copper.* Cu is extracted from solid CuCl suspended in an electrolyte; strong current produces a crystalline spongy Cu mass.

(965) U. S. 689,835 (1901). G. H. Waterbury and F. Williams, *Process of Extracting Copper from Ores.* Precipitation of Cu in form of slimes is rapidly effected by passing compressed heated air upward through precipitant and solution.

(966) U. S. 723,949 (1903). G.D. Van Arsdale, *Process of Separating Copper from Ore.* Metallic Cu is precipitated from solution containing $CuSO_4$ by impregnating the solution with SO_2 and heating.

(967) U. S. 790,238 (1905). H. M. Wilcox (Esmeralda Copper Precipitating Co.), *Method of Recovering Copper from Ores.* Metallic Cu is precipitated from $CuSO_4$ solution by dosing with SO_2 in a closed vessel, under heat and pressure.

(968) U. S. 793,186 (1905). G. Gin, *Process of Extracting Copper From Ore.* Metallic Cu is precipitated from cuprosocupric sulfite dissolved in H_2SO_3 on heating under pressure.

(969) U. S. 805,969 (1905). N. V. Hybinette, *Separation of Metals.* To separate Ni-Cu alloy, an anode of the alloy is electrolyzed in $NiSO_4$ and weak acid solution, and Cu is cemented out of the solution.

(970) French 367,863 (1906). T. A. Edison, *Manufacture of Cobalt Pellicles.* Process consists in alternately forming on the cathode pellicles first from one metal, *e.g.* Co, and then pellicles of Cu, followed by removing the pieces from the cathode to dissolve the Cu without attacking the Co.

(971) French 367,863 (1907). T. A. Edison, *Process of Making Films or Flakes of Copper or Nickel. Cf:* U.S. 936,525 (No. 566).

(972) U. S. 870,786 (1907). L. Jumau, *Process of Obtaining Pure Copper.* Pure Cu is precipitated from a Cu salt which is heated under pressure with a sulfite.

(973) U. S. 894,902 (1908). W. B. Potter (Esmeralda Copper Precipitating Co.), *Method of Recovering Copper.* Metallic Cu is precipitated from $CuSO_4$ solution charged with SO_2 and subjected to heat and pressure: the spongy product may be pressed into ingot form without further refining.

(974) U. S. 924,076 (1909). L. Jumau, *Process for Obtaining Pure Copper.* Pure metallic Cu is precipitated from Cu salt solution by treatment with CO gas, under heat and pressure.

(975) U. S. 924,077 (1909). L. Jumau, *Process for Obtaining Pure Copper.* Same process as in U. S. 924,076 (No. 974), but the reducing agent used is H_2 instead of CO.

(976) U. S. 930,967; 930,968 (1909). L. Jumau, *Process for Obtaining Pure Copper.* Cu salt solution is heated, under pressure, to a high temperature in the presence of H_2SO_3, and pure metallic Cu is precipitated.

(977) U. S. 949,003 (1910). A. S. Ramage (Chemical Development Co.), *Process of Producing Electrolytic Copper.* H_2 and water gas are passed over Cu ores at low red heat, and the resulting product is used for the electrolysis.

(978) Brit. 6161/1913 (1913). T. J. I. Craig, *Copper Powder.* It is produced electrolytically with a Cu-anode and Pb-cathode. The electrolyte is an acid solution of titanic sulfate containing 6% Ti-salt and 6% H_2SO_4.

(979) U. S. 1,069,981 (1913). E. Schaaf and S. G. Martin (W. O. Bartholomeo), *Method for Recovering Copper.* Comminuted or finely divided Cu is precipitated from a Cu-solution by charging it with gaseous peroxide and lower oxides of N and subjecting it to heat and pressure.

(980) U. S. 1,089,096 (1914). E. R. Weidlein (Metals Research Co.), *Hydrometallurgy of Copper.* Metallic Cu is precipitated by SO_2 from a $CuSO_4$ solution; Cu powder may be compressed to form anodes.

(981) U. S. 1,128,313 (1915). N. V. Hybinette (National Trust Co.), *Process of Separating Copper from Nickel and Matte.* Cu and Ni are separated by cementing the Cu on a Cu-Ni-S slab prepared for spongy deposit by having previously been made porous in an electrolytic bath.

(982) U. S. 1,147,466 (1915). G.D. Van Arsdale, *Process of Precipitating Copper.* Cu is precipitated from solution by adding SO_2 thereto and neutralizing the free acid formed during precipitation.

(983) U. S. 1,201,899 (1916). E. R. Weidlein, *Metallurgy of Copper.* Cu is precipitated from a H_2SO_4 solution by means of SO_2 in a continuous manner by heating to effect the precipitation and recirculation with fresh solution.

(984) U. S. 1,223,454 (1917). E. R. Weidlein, *Recovery of Copper.* The apparatus for the precipitation of Cu comprises a tank with means for heating for the circulation of the solution under pressure.

(985) U. S. 1,254,056 (1918). W. C. Moore (National Carbon Co.), *Metal Powder Such as Copper.* A solution of $CuSO_4$ in water is electrolyzed to form spongy metal, which is washed in solution of glucose or other colloid and dried *in vacuo* to obtain the powdered metal.

(986) U. S. 1,257,943 (1918). W. T. Howard, *Treatment of Copper for Various Purposes.* Open-textured soft Cu is produced by precipitation in divided state from solution of Cu-salt with finely grained Fe, followed by washing and pressing into aggregate of specific gravity less than that of compact Cu.

(987) German 318,177 (1919). H. Schlink & Co., *Production of Very Fine Nickel.* Ni powder is produced in an electrically heated furnace,containing several plates, one upon the other, by reduction with H_2 atmosphere.

(988) U. S. 1,291,030 (1919). C. Langer, *Process of Refining Nickel-Copper-Matte.* Ni-Cu matte is separated by precipitating Cu from acid solution using finely divided Ni, reduced from the original matte, as the precipitant, and electrolyzing the residual solution.

(989) U. S. 1,326,463 (1919). J. J. Nelson, *Process for Bleaching Copper Ores.* Cu is precipitated from a Na_2SO_4–NaCl solution with finely divided steel as precipitant; additional NaCl prevents adherence of Cu to steel.

(990) U. S. 1,382,361 (1921). N. V. Hybinette and R. L. Peek, *Refining Copper-Nickel Matte.* Cu-Ni matte is leached of the greater part of the Cu and part of the remaining matte is reduced to metal powder onto which the Cu leached out by the electrolyte is cemented, thus purifying the electrolyte.

(991) U. S. 1,395,755 (1921). G. A. Bragg (Metals Research Co.), *Hydrometallurgy of Copper.* To prevent adherence of Cu to the walls of the precipitating chamber, SO_2 is introduced into hot rather than cold $CuSO_4$ solution.

(992) Japan. 41,893 (1922). T. Ito and H. Kawasaki, *Apparatus for Reducing Nickel.* A horizontal cylinder having agitating wings is fitted with a conduit pipe containing a screw conveyer to reduce NiO traveling from one end of the cylinder to the other without exposing it to air.

(993) U. S. 1,416,147 (1922). H. M. Wilcox (F.C.L. D'Aix), *Method and Apparatus for Recovering Copper.* Method and apparatus for precipitating metallic Cu as a continuous operation are claimed.

(994) U. S. 1,423,070 (1922). H. Bardt (Sociedad Hidro Metallurgica), *Process for Precipitating Metals such as Copper.* Fine powdered Cu precipitate, free of metallic contaminants such as Fe, is produced by using sugar waste liquors, etc., containing polysaccharides as precipitants.

(995) U. S. 1,430,140 (1922). F. S. Adams, *Process and Apparatus for Precipitating Copper.* Method and apparatus are claimed for increasing precipitation of metallic Cu by return to the solution of gas and steam collecting above the $CuSO_4$ solution during introduction of SO_2.

(996) U. S. 1,461,918 (1923). F. Laist (Anaconda Copper Mining Co.), *Hydrometallurgical Precipitation of Copper.* Cu, free from S compounds, is precipitated from $CuSO_4$ solution by adding SO_2 in liquid rather than vapor phase which enables its quick entry into solution.

(997) U. S. 1,472,115 (1923). L. F. Clark, *Process of Treating Solutions of Copper.* Metallic Cu is precipitated under high temperature and pressure by formic acid or aliphatic aldehydes, etc., eliminating regeneration of free H_2SO_4.

(998) German 431,437 (1926). E. Seyfferth, *Producing Copper Powder.* Method of producing Cu powder by heating copper formate in retort in inert gas or vacuum to 400° C. (750° F.).

(999) U. S. 1,592,173 (1926). H. Bardt, *Process for Reduction of Metallic Salt Solution.* Metallic, crystalline Cu is precipitated from Cu-salt solutions by heating them with cellulose material which has been treated with an inorganic liquid acid (H_2SO_4) reacting under heat and pressure.

(1000) Brit. 271,853 (1927). Copper Deoxidation Corp., *Copper Powder.* Method of production comprises removing surface impurities of Cu in non-injurious atmosphere and subjecting particles to high enough pressure to press the surfaces into contact at temperatures sufficient to cause crystal growth.

(1001) German 454,804 (1927). Gebr. Siemens & Co., *Preparing of Cobalt.* Method comprises precipitation of Co out of an aqueous solution by means of Fe, followed by reduction with H_2 at red heat.

(1002) U. S. 1,628,190 (1927). M. Raney, *Method of Producing Nickel.* Metallic Ni in catalytic state is produced by alloying it with Al and dissolving the latter.

(1003) U. S. 1,639,610 (1927). K. Mattenklodt and H. Schramm (Duisburger Kupferhütte), *Recovery of Copper.* Cement-Cu is precipitated from solution containing chlorides and sulfates and other metal salts.

(1004) U. S. 1,643,922 (1927). N. Christensen, *Process of Precipitating Copper.* Cu is precipitated from sulfate solution by tumbling with Pb-shot, while continuously freeing the shot of sulfate coating.

(1005) French 638,013 (1928). Comp. Generale D'Electricité, *Manufacturing of Nickel Flakes.* Process comprises forming a sheet of coherent layers of Ni by anodically polarizing the surface of each deposit, cutting the product in small pieces, and subjecting the pieces to the action of a weak acid solution, to produce active material for alkaline accumulators.

(1006) U. S. 1,671,004 (1928). A. B. Bagsar, *Process for Extracting Nickel.* Ni is precipitated from $NiCl_2$ by powdery Zn, the reaction being speeded by keeping the temperature at 40-90° C. (105-195° F.) or higher.

(1007) U. S. 1,732,179 (1929). E. Bruening and O. Schneider (Electric Storage Battery Co.), *Manufacturing of Nickel Flakes. Cf.:* French 638,013 (No. 1005).

(1008) German 511,564 (1930). I. G. Farbenindustrie A. G., C. Müller and W. Schubardt, *Pure Nickel and Cobalt Powders.* Decomposition of carbonyls of Ni and Co is controlled to give pure powders.

(1009) U. S. 1,753,015 (1930). A. G. McGregor, *Precipitation System for Copper Powder.* Plant and process are claimed for precipitating Cu by Fe from acid solution in which batches of Fe are disposed in series so that the solution passes from the oldest batch to newer ones.

(1010) U. S. 1,777,371 (1930). W. Koehler (Koehler Chemical Works), *Feathery Copper Powder and Process of Producing Same.* Cu powder produced by process claimed is uniform and regular in size, the particles having the property of matting together under pressure.

(1011) French 709,124 (1931). Vitriolfabrik Johannisthal A. G., *Powdered Copper.* Powdered Cu is oxidized by gas and the oxided particles are separated from the metal.

(1012) German 563,184 (1932). Vitriolfabrik Johannisthal A. G., *Production of Copper Powder.* A solution of Cu or its alloys is mixed with sawdust to precipitate the metal salt, which is heated in air to expel the organic material, and then reduced.

(1013) German 566,448 (1932). I.G. Farbenindustrie A.G., G. Hamprecht, L. Schlecht and F. Spoun, *Cobalt Powder from Cobalt Nitrosocarbonyl.* CO is passed over Co or material containing Co in presence of oxide of Ni-carbonyl, and resulting product is decomposed to Co.

(1014) U. S. 1,856,661 (1932). C. F. Sherwood (Moraine Products Co.), *Copper Powder.* Fe is used to precipitate Cu from solution of $CuSO_4$ prepared by dissolving Cu-scraps in dilute H_2SO_4.

(1015) Brit. 401,438 (1933). I. G. Farbenindustrie A. G., *Production of Nickel Carbonyls.* Compacted Ni is reacted with CO at a pressure of 20 atm. at 100-200° C. (210-390° F.).

(1016) French 750,097 (1933). Soc. Générale de Construction Electriques et Méchaniques, *Production of Pure Cobalt.* Method comprises electrolysis of a solution of salt of Co.

(1017) U. S. 2,008,373 (1935). H. E. Tobelmann, *Precipitation of Copper from Solution.* Precipitated Cu is purified by re-dissolving the finer and impure portion and reprecipitating.

(1018) U. S. 2,068,296 (1937). F. Lausberg (Dr. Kurt Albert G.m.b.H.), *Precipitation of Copper.* From Monel metal scrap, dissolved in H_2SO_4, Cu is precipitated at a temperature above 100° C. (212° F.), and under pressure.

(1019) U. S. 2,084,154 (1937). R. P. Lutz (Western Electric Co.), *Copper Powder.* Cu-wire is drawn with a drawing compound of fat and soap, so that Cu-containing sludge is formed. This is treated with a solvent, and the Cu-powder is filtered off.

(1020) U. S. 2,170,814 (1939). J. E. Drapeau, Jr. (Glidden Co.), *Production of Copper Powder.* Pure Cu surface is oxidized to Cu_2O, milled off, and reduced.

(1021) German 688,435 (1940). I. G. Farbenindustrie A. G., *Production of Nickel with Low Carbon Content.* The C content of Ni powder is reduced by fractionally distilling the carbonyl so that its content of Fe-carbonyl and C is less than 0.3%.

(1022) U. S. 2,189,263 (1940). G. Hamprecht, and G. Pauckner (I. G. Farbenindustrie A. G.), *Precipitation of Copper.* In its electrolytically deposited form, Ni is found to be a quicker precipitant for Cu than Ni remelted after deposition.

(1023) U. S. 2,213,864 (1940). A. C. Jephson (Lincoln Niagara Corp.), *Recovery of Copper from Brass.* Cu in powdered form is recovered from scrap brass by electrolysis.

(1024) U. S. 2,233,103 (1941). C. L. Mantell (Hardy Metallurgical Co.), *Production of Nickel Powder.* Method claimed is electrolytic production of Ni powder in an alkaline aqueous solution of alkali ions, nickel-ammonium ions and chloride ions whereby Ni tends to be dissolved from anode and deposited at cathode.

(1025) U. S. 2,252,714 (1941). E. J. Hall (Metals Disintegrating Co.), *Reduction of Powdered Metals Such as Copper.* Method comprises producing a friable mass of Cu by passing a horizontally moving stream of a reducing gas over a ribbon-like stream of heated Cu_2O, moving horizontally in the opposite direction and thereafter having the stream of Cu travel through a cool non-oxidizing gas.

(1026) Brit. 545,962 (1942). Mond Nickel Co., *Production of Nickel Flakes.* The Ni is deposited on a cathode to which the deposit adheres feebly from the bath of a Ni salt at a temperature of 10-20° C. (50-68° F.) and with a current density of 20-40 amp. per sq. ft.

(1027) U. S. 2,285,762 (1942). S. B. Tuwiner (Phelps Dodge Corp.), *Metallic Copper.* Metallic Cu in fine flake form is made by electrodeposition of the metal upon a cathode having a film of oxidized castor oil.

(1028) German 742,426 (1943). Vereinigte Deutsche Metallwerke A. G., *Nickel Powder by Purification of Nickel Carbonate.* Ni powder with 99.6% Ni is obtained by heating a ball-milled mixture of $NiCO_3$ and 1-2% NaOH at 450° C. (840° F.) for 4 hours and rinsing with water at 70° C. (160° F.).

(1029) U. S. 2,324,960 (1943). C. R. G. Stewart (Western Electric Co.), *Recovering Copper Dust from Wire-Mill Sludge.* Method comprises heating and stirring the sludge for a predetermined time to separate the dust in the sludge from the fats and permitting the mixture to settle, to effect a partial separation, and repeating the operation.

(1030) Brit. 558,722 (1944). F. W. Berk & Co. Ltd. and E. Mehl, *Manufacture of Copper Powder.* Cu powder is electrodeposited cathodically from an acid reacting chloride electrolyte by use of a brass anode containing at least 25% Zn.

(1031) U. S. 2,347,450 (1944). J. H. Young (E. I. Du Pont de Nemours & Co.), *Production of Copper Sponge.* Cu sponge deposited from bath of alkali metal and copper cyanide at 600° C. (1110° F.) is readily disintegrated to Cu powder.

(1032) U. S. 2,352,096 (1944). J.O. Hay (Harshaw Chemical Co.), *Chemical Separation of Copper.* Chemical separation and recovery of Cu from metals electropositive to the latter is obtained by treating an aqueous acid solution of Cu and metal salt.

(1033) U. S. 2,365,356 (1944). N. B. Pilling and A. Wesley (International Nickel Co.), *Nickel Electroflake Pigment.* Pure Ni powder is produced by electrodeposition, using Ni-anodes insoluble in the electrolyte, so that the deposited Ni is so brittle that the 40-mesh particles can be crushed to a size passing all through a 325-mesh screen.

(1034) Canadian 441,144; 441,145; 441,146 (1945). W. J. Kroll, *Nickel Refining Method.* Impurities are removed from Ni by treating it in a comminuted form in a fused KCl-NaCl bath at 700° C. (1290° F.), and passing a slow current of Cl through the bath. Process also comprises mixing Ni with an excess of anhydrous $NiCl_2$.

(1035) U. S. 2,367.022 (1945). J. O. Hay (Harshaw Chemical Co.), *Separation of Copper from other Metals.* Method comprises separation of Cu from its mixture with a more electropositive metal, such as Sn, by using an aqueous acid solution.

(1036) U. S. 2,367,239 (1945). L. S. Renzoni (International Nickel Co.), *Purification of Cobalt Precipitates.* Purification of Co precipitates containing Pb, Fe, Cu, and Ni, with SO_2 as reducing agent is claimed.

(1037) Brit. 576,144 (1946). The Mond Nickel Co. Ltd., *Production of Nickel or Cobalt in Form of Flakes.* The metal is electrolytically deposited in laminated form from an electrolyte containing thiourea and subsequently converted into flakes.

(1038) U. S. 2,396,792 (1946). W. J. Kroll, *Refining Nickel.* Process comprises treating a molten metal chloride bath containing $NiCl_2$ to remove Ni content as metallic Ni by incorporating in the bath a finely divided metallic material of a melting point higher than that of the bath.

(1039) U. S. 2,396,793 (1946). W. J. Kroll, *Scrap Metal Recovery of Nickel.* Method comprises treating Ni and Ni alloys to remove associated metal impurities by comminuting metal and suspending it in a molten metal chloride fusion consisting of the chloride compound and a metal relatively high in the displacement series of metals, and passing gaseous chlorine into and through the fusion at a slow rate while maintaining a temperature within a range of 500-1000° C. (930-1830° F.) until the impurities have been almost completely converted into metal chlorides.

(1040) U. S. 2,396,794 (1946). W. J. Kroll, *Refining Nickel.* Method comprises treating impure Ni by comminuting, mixing with anhydrous $NiCl_2$, compacting, heating in inert atmosphere to 500-1000° C. (930-1830° F.) to convert major portion of impurities into metal chloride compounds by displacement reaction with $NiCl_2$, and separating the Ni from the chloride.

(1041) Brit. 591,801 (1947). Pyrites Co. Ltd., *Method of Recovering Copper.* It comprises adding metallic Cu in presence of Cl as a dissolved chloride to the solution, so that CuCl is precipitated, separating it, and thereafter treating it with Fe for recovery of the Cu.

(1042) U. S. 2,420,540 (1947). S. Hubbell (H. H. Robertson Co.), *Cuprous Powder.* A cuprous powder stable in the air, highly reactive and providing a source of available Cu is claimed which comprises a finely divided cuprous powder, the major portion of the particles being a few microns in size and having as principal constituent friable metallic Cu-core particles surrounded by protective surface films of Cu_2O which inhibit oxidation in the air.

(1043) Brit. 601,113 (1948). E. Lux, *Aluminothermic Reduction of Manganese.* Mn powder is produced by reaction of a thermic mixture of MnO and MnO_2, with an

O content of 30%; the escaping Mn vapors are condensed and may be re-used as oxides.

(1044) Swedish 121,682 (1948). J. F. Heuberger, *Metal Powders.* Cu is obtained as a fine powder for sintering processes by grinding CuO and then repeatedly reducing and oxidizing it, the reduction steps being carried out at progressively lower temperatures.

(1045) U. S. 2,440,612 (1948). M. Lichtenwalter (Nicaro Nickel Co.), *Separation of Copper.* Process for separately recovering the Cu and Ni content from ammoniacal ammonium carbonate comprises leaching the solution until the Cu is reduced to the cuprous state, and the Ni precipitated is free from Cu.

(1046) Brit. 618,262 (1949). O. Jestrabek, *Extraction of Copper.* Cu powder having a particle size of 2-3 microns is made from Cu-alloy scrap by dissolving it in aqueous cuprammonium solution, adding Na_2CO_3, passing CO_2, and evaporating.

(1047) Brit. 620,287 (1949). Mond Nickel Co. Ltd. and A. E. Wallis, *Decomposition of Nickel Carbonyl.* Ni-carbonyl is fed into a decomposer counter-currently to the motion of Ni-pellets, which are preheated to 240° C. (465° F.) and are caused to flow in counter-current to a gas containing the $Ni(CO)_4$ so as to decompose it to yield Ni powder which is cooled.

(1048) Brit. Appl. 5449/49 (1949). D. Primavesi, *Production of Electrolytic Copper Powder.* Powder is made from Cu-alloy scrap in a $FeCl_2$ bath containing CuCl. A Cu-cathode is used to which the deposits adhere.

(1049) U. S. 2,461,396 (1949). M. Raney, *Method of Producing Finely Divided Metals.* Process of forming non-pyrophoric Ni powder consists of exothermally decomposing finely divided catalytically active hydrided Ni-powder at atmospheric pressure, in an atmosphere selected from the group consisting of CO_2 and H_2, by heating it therein to a temperature of about 200° C. (400° F.) to start the exothermal decomposition, and holding its temperature within the range 200-650° C. (400-1200° F.) during the decomposition and until cessation of evolution of H_2 therefrom.

(1050) U. S. 2,463,190 (1949). A. E. Lundbye (Crowell-Collier Publ. Co.), *Method of Producing Nickel Powder from Printing Press Plates and the Like.* Printing press plates are placed in an electrolytic bath consisting essentially of a 3% to 25% HCl solution containing a buffering agent; Ni is electrolytically stripped from the plates as anodes; H_2S is passed through the bath to precipitate all the metals forming the plate except the Ni, while maintaining the pH value at not more than 4.

(1051) U. S. 2,475,676 (1949). F. E. Ralph (Anaconda Copper Mining Co.), *Apparatus for the Recovery of Copper.* Powdered Cu precipitated on Fe from Cu-bearing mine water may be recovered with this apparatus. It comprises a long narrow downward sloping launder which contains the Fe and carries a flowing stream of mine water in contact with the metal; a slusher travels along the launder and it may be driven back and forth along the launder; nozzles on the slusher are directed downward toward the Fe and in the direction of flow of the mine water.

(1052) U. S. 2,477,553 (1949). C. H. McKeever (Rohm & Haas Co.), *Use of a Promoter in the Manufacture of Cobalt Carbonyl.* The product is prepared by suspending finely divided cobalt basic carbonate in a neutral organic liquid. Before a reaction takes place, from 0.25 to 6.0% of pre-formed $Co(CO)_4$ based on the weight of the cobalt basic carbonate is initially present in the reactor. Carbonyl is suitable for thermal decomposition into Co powder.

(1053) U. S. 2,477,554 (1949). C. H. McKeever (Rohm & Haas Co.), *Process of Preparing Cobalt Carbonyl.* It comprises dissolving a toluene-soluble Co-salt of an organic acid in an inert solvent, and reacting the dissolved Co-salt with CO and under superatmospheric pressure. Carbonyl is then suitable for thermal decomposition into Co powder.

(1054) U. S. 2,480,771 (1949). L. S. Renzoni (The International Nickel Co.) *Process For The Electrolytic Recovery of Nickel.* A novel liberator cell is employed with insoluble anodes and a chloride ion-containing electrolyte whereby the electrolytic system can be operated in balance, with respect to Ni, during the electrolysis. Ni powder is recovered by electrodeposition at a cathode without liberation of Cl at an insoluble anode.

v. Low-Melting Metals (Zinc, Lead, Tin, Cadmium, Antimony, Bismuth, Calcium, Indium, Thallium)

(1055) Brit. 1,502/1893 (1893). E. Correns and W. P. Thompson, *Process for Producing Finely Subdivided Lead.* Pb-compounds are mixed in pulverulent condition with diluted H_2SO_4 and formed into plates which are immersed in an electrolyte bath of diluted H_2SO_4. The Pb-compounds are then reduced to Pb-mud.

(1056) German 70,348 (1893). Electriciteits Maatschappy System De Khotinsky, *Production of Lead Dust.* The fluid metal is carried through the nozzle by vapor or compressed air which warms it up.

(1057) German 71,431; 71,679 (1893). Berliner Accumulatoren-Werke, *Powdered Lead.* Material is produced electrolytically.

(1058) German 86,983 (1896). Elektrizitäts Ges. Gelnhausen, *Production of Lead Dust.* Addition to German 70,348 (No. 1056) by using a nozzle for the fluid metal which is surrounded by nozzles for the atomizing, the jets of vapor or gas penetrate from all sides into the metal jet.

(1059) German 88,273 (1894). Allgemeine Elektrizitäts-Aktiengesellschaft, *Electrolytic Production of Metallic Crystals.* Sn is produced by electrolysis using Sn-salt containing $FeCl_3$ or $Fe_2(SO_4)_3$.

(1060) U. S. 598,313 (1898). E. P. Clark and C. S. Campbell, *Electrodeposition of Lead.* Process produces finely divided Pb by putting Zn into solution of acetate of Pb, and passing current from Pb-anode to deposit finely divided Pb upon cathode.

(1061) Brit. 15,207/1899 (1899). P. Neumann, *Production of Lead.* Pb-acetate is placed in centrifugal apparatus and Pb precipitated as a spongy metal by the use of Zn.

(1062) U. S. 846,384 (1907). J. W. Bailey (United Lead Co.), *Lead Product.* Metallic Pb is subjected to action of rapidly moving beaters; conveyed by currents of air or gas, and while in suspension, uniformly subjected to the action of chemical agents if the material is desired for Pb pigments.

(1063) U. S. 923,411 (1909). S. Cowper-Coles, *Manufacture of Zinc Dust.* Method produces Zn-dust by electrodeposition of Zn from caustic soda solution.

(1064) German 229,648 (1910). R. Ipsen, *Separation of Zinc Dust from Zinc Muffle Gases.* Breakers in furnace for Zn are formed as collectors for dust.

(1065) Brit. 13,756/1910 (1911). R. H. A. Plimmer, *Antimony.* Sb powder, for application in medicine, is produced by an electrolytic method.

(1066) Brit. 9,968/1911 (1911). R. C. V. Whitfield, *Powdered Antimony.* Process is claimed for production of metallic Sb from ore wherein $SbCl_3$ is electrolyzed between an Fe-anode and insoluble cathode.

(1067) German 239,788 (1911). A. Sadlon, *Zinc Dust Receiver.* Apparatus consists of a balloon for the collection of Zn dust, with separators on the sides.

(1068) Brit. 5,196/1911 (1912). Central Zinc Co., Ltd., J. C. Moulden and H. W. Webster, *Zinc Distillation.* Process comprises distilling Zn by placing NaCl in the path of retort vapors and thereafter separating the blue powder in presence of an haloid salt to reduce the product to metallic Zn.

(1069) Brit. 19,973/1911; 21,014/1911 (1912). C. V. Thierry, *Production of Zinc Blue Powder or Refined Zinc Oxide.* Method consists of charging an electrical furnace with oxide of Zn and C in such proportion that all of the charge is evolved by reaction in form of fumes.

(1070) French 458,111 (1912). E. F. Côte and P. R. Pierron, *Smelting Zinc Powder or Zinc Dust.* Mixture of Zn dust with NaCl in an air-tight chamber is heated to 450-500° C. (840-930° F.).

(1071) U. S. 1,141,177 (1915). C. Ellis (Ellis-Foster Co.), *Process for Treating Lead.* Molten Pb is exploded by a jet of steam.

(1072) U. S. 1,156,079 (1915). C. D. Holley (Acme White Lead & Color Works), *Process for Comminuting Lead.* Molten Pb and a jet of superheated steam are forced into an expansion chamber.

(1073) U. S. 1,194,438 (1916). R. H. Stevens (U. S. Smelting, Refining & Mining Co.), *Process for Separating Metals such as Cadmium.* In a process for its recovery from ores, flue dusts, etc., metallic Cd is deposited on the cathode in coherent form, or in noncoherent form which falls from the cathode.

(1074) Brit. 105,558 (1917). Norsk Elektrisk Metalindustri, *Converting Zinc Powder into Molten Zinc.* Method of converting Zn-powder into liquid Zn consists in subjecting powder without addition of flux to a rubbing action in internally heated furnace.

(1075) French 484,946 (1917). Norsk Elektrisk Metalindustri, *Converting Zinc Powder into Molten Zinc. Cf.:* Brit. 105,558 (No. 1074).

(1076) U. S. 1,266,808 (1918). S. Huldt (Norsk Elektrisk Metalindustri, *Liquid Zinc from Zinc Powder.* Method comprises heating Zn-powder and subjecting it to rubbing operation by rotation of the furnace.

(1077) Brit. 124,621 (1919). C. Crocker and C. W. Crocker, *Extracting Zinc Dust.* The introduction of Na_2CO_3 as a flux into the charge in a Zn distillation furnace is claimed.

(1078) Brit. 129,392 (1919). J. Nelson and W. C. White, *Lead Powder.* Powdered Pb is obtained by precipitating amorphous Pb from solution of Pb by means of powdered Zn.

(1079) U. S. 1,295,573 (1919). M. H. Newell (The Alloys Co.), *Apparatus for Producing Metal Dust From Zinc.* Vaporizing under large hood and condensing are claimed.

(1080) U. S. 1,299,445 (1919). F. F. Farnham (National Metal Molding Co.), *Method of Producing Blue Powder.* Material is obtained from highly heated Zn-fumes by continuous condensation.

(1081) Brit. 155,572 (1921). R. Seiffert, *Manufacture of Zinc.* Process is improved with a view to increasing the yield of Zn-dust.

(1082) Brit. 170,026; 171,722 (1921). C. E. Cornelius, *Distilling Zinc and Lead.* Method comprises cooling Zn vapors coming from the reduction furnace to a temperature considerably below the melting point so that vapors are converted into powder form.

(1083) Japan 40,828 (1921). K. Matsuo and S. Saito, *Pure Powdered Lead.* Sponge Pb is prepared by electrolysis of $Pb(NO_3)_2$ solution; adding of 10% sugar prevents the oxidation and eases the process.

(1084) Japan 41,177 (1921). J. Ohshima (The Furukawa Denki Kogyo Kabushiki Kaisha), *Lead Powder.* A solution of Pb-benzene is electrolyzed with Pb electrodes at 2-5 volt, and the mass is then dried.

(1085) Brit. 171,962 (1922). Rheinisch-Nassauische Bergwerks- & Hütten A. G., and A. Spieker, *Zinc Powder.* Process for producing Zn powder by treatment with acids is claimed.

(1086) Canadian 226,928; 226,929 (1922). E. S. Berglund, *Method of Converting Zinc Powder. Cf.:* U. S. 1,506,609 (No. 1096).

(1087) Japan 41,728 (1922). G. Shimadzu, *Lead Powder.* Pb-balls are rotated in a cylindrical vessel which sometimes is cooled; the product is an amorphous fine powder, the fineness being regulated by changing the diameter of the balls.

(1088) Japan 42,562; 42,563; 42,564 (1922). G. Shimadzu, *Reactive Lead Powder.* Improvement of Japan 41,728 (No. 1087); the vessel has projecting orifices for the air, instead of perforations, and a discharge opening is provided; air under 2.5 lb. pressure is blown in.

(1089) Japan 42,672 (1922). G. Shimadzu, *Zinc Dust.* A cylindrical vessel contains 500 steel balls and 1000 kg Zn-balls of the same diameter; during the revolution air is blown in to produce a homogeneous Zn-powder.

(1090) Swedish 52,656 (1922). Finspongs Metallverks A. B., *Smelting Zinc Dust to Liquid Zinc.* Zinc-dust is charged continuously into an electric furnace, and the residue of ZnO is removed.

(1091) U. S. 1,412,621 (1922). F. P. Lannon (American Smelting & Refining Co.), *Process and Apparatus for Treating Zn-Dust.* Blue Zn-powder is produced by vaporizing.

(1092) U. S. 1,425,6C1 (1922). T. Kato, *Process for Manufacturing Zinc Dust.* Volatilizing metallic Zn in retort is claimed.

(1093) U. S. 1,429,330 (1922). J. T. Ellsworth, *Recovering of Zinc from Complex Ores.* Method comprises treating the ores with a cyclic solvent solution and electrodeposition of Zn therefrom, regulating the concentration of the soluble salts in the cyclic solution prior to electrolysis to avoid supersaturated solutions.

(1094) U. S. 1,480,110 (1924). M. G. Platten, *Process for Producing Metallic Lead.* Spongy Pb is precipitated by passing a pregnant brine solution over metallic Fe.

(1095) U. S. 1,487,125 (1924). I. R. Stack, *Process of Recovering Tin.* In process of refining impure Sn bullion, elements such as As and Pb are precipitated as compounds and Bi as a metal powder.

(1096) U. S. 1,506,609 (1924). E. S. Berglund, *Method of Converting Zinc Powder.* Zn-powder is converted to fluid Zn by stirring the powder as it comes from the condenser pipe, and subjecting it to centrifugal force.

(1097) U. S. 1,510,071 (1924). F. J. A. Wennergren and F. Andersen, (Trollhättans Elektrothermiska A. B.), *Apparatus for Producing Zn-Powder.* Furnace and condenser system for producing Zn-powder are claimed.

(1098) Canadian 245,563 (1925). F. Tharaldsen, *Process for Making Liquid Zinc from Blue Powder. Cf.:* U. S. 1,535,059 (No. 1101).

(1099) Norw. 41,381 (1925). F. Tharaldsen, *Treating Zinc Powder in a Moving Container.* The rotary drum is provided with projections which act upon the pulverulent mass while the drum is in rotation.

(1100) Norw. 41,476 (1925). T. Gjerstadt, *Condensing Zinc and Cadmium.* The gas mixture from a metallurgical furnace has a spinning rotation by introducing it with great velocity in tangential direction into the lower part of a cylindrical or conic condenser through slits in the circuit.

(1101) U. S. 1,535,059 (1925). F. Tharaldsen, *Process for Making Liquid Zinc from Blue Powder.* Blue powder is subjected to revolving action of a heated rotary drum, and a series of shocks is imparted to the drum, thereby causing a settling of the non-oxidized metal away from the powder.

(1102) U. S. 1,546,926 (1925). E. H. Gaughan, *Process of Making Powdered Zinc.* It comprises conducting molten Zn through a tube at whose end a heated liquid is applied under pressure. Size of Zn-particles may be varied.

(1103) U. S. 1,548,854 (1925). H. M. Schleicher (American Metal Co.), *Production of Antimony.* Metallic Sb is obtained by reduction of sodium pyroantimonate to an alloy of Sb and Na which is pulverized and washed with water to remove the Na.

(1104) U. S. 1,584,149 (1926). G. Shimadzu, *Method of Manufacturing Metal Powder.* Finely divided chemically reactive Pb is formed by rotating a vessel containing molten Pb at low speed, thus causing the Pb-masses to form a powder by rubbing action.

(1105) Brit. 265,036 (1927). E. C. R. Marks (American Smelting & Refining Co.), *Zinc from Blue Powder.* Recovery of Zn from the blue powder residues of Pb-refining comprises heating the slag to separate and collect volatilized products therefrom, while $ZnCl_2$ is precipitated.

(1106) Brit. 265,558 (1927). Fried. Krupp Grusonwerk A. G., *Treating Zinc Dust.* Zinciferrous flue dust is fed into flame furnace subjected to a temperature high enough to effect a sintering of the metal, and its deliberate purification by volatilization of detrimental secondary constituents.

(1107) Norw. 43,745 (1927). F. Tharaldsen, *Converting Zinc Dust to Liquid Zinc.* Powder is treated in a horizontally rotary drum which is subjected to a vigorous shaking vertical to its axis.

(1108) U. S. 1,647,381 (1927). N. F. Tharaldsen, *Process for Making Liquid Zinc from Blue Powder.* Method comprises superimposing a mass of blue powder upon a bath of liquid Zn and raising portions of the liquid Zn above the powder and pouring it over the latter.

(1109) Norw. 44,762 (1928). Aktieselskapet Malmindustri, *Converting Zinc Dust Into Liquid Zinc.* Mechanical features of converter are given.

(1110) U. S. 1,688,426 (1928). F. P. Lannon (American Smelting & Refining Co.), *Method and Apparatus for Producing Zinc Dust.* Zn powder is produced from Zn-fumes by condensation.

(1111) German 487,700 (1929). G. Shimadzu, *Apparatus for Producing Lead Dust.* Method comprises comminuting of Pb in a milling drum, through which air is blown to carry away the dust.

(1112) Norw. 47,347 (1930). F. Tharaldsen, *Converting Zinc Dust to Liquid Zinc.* Molten Zn is poured through Zn dust in a horizontally rotary drum with paddles or pockets forcing the dust down into the liquid Zn.

(1113) U. S. 1,762,716 (1930). H. A. Grine (Grasselli Chemical Co.), *Process of Preparing Zinc Dust and Apparatus Therefore.* Method comprises distillation of metallic Zn-bearing material and condensing.

(1114) Brit. 362,129 (1931). Y. Takata, *Pulverized Lead.* Process for producing pulverized Pb consists in atomizing molten Pb by compressed air and causing it to impinge on revolving blades of a fan.

(1115) German 531,392 (1931). H. Heinicke and K. Heimberger, *Vaporization Apparatus for Converting Lead and Lead Oxide Into Lead Dust.* Apparatus consists of a vessel for the evaporation of the Pb with a delivery pipe into which a nozzle is inserted, to feed cooling and reducing gases into the separator for the Pb-dust.

(1116) German 538,830 (1931). G. Shimadzu, *Apparatus for Producing Lead Dust.* Apparatus consists of a grinding drum with a hollow main shaft through which the air intake is conveyed, having discharges arranged toward the lower end and ending in the front wall of the drum.

(1117) U. S. 1,839,800 (1932). W. S. Murray (Oneida Co.), *Recovery of Indium.* In recovering In and Zn from ore by electrolysis, Zn-dust is used to precipitate metals such as In, Au and Ag.

(1118) U. S. 1,869,214 (1932). St. Hughes and R. Teats (American Smelting & Refining Co.), *Process of Recovering Thallium.* Flaky metallic Tl is recovered from $CdSO_4$ solution utilized in the manufacture of Cd, by first producing Tl_2SO_4 which may then be electrolyzed.

(1119) U. S. 1,874,253 (1932). V. L. Dickson, *Breaking Down of Metals.* Comminuting Pb is accomplished by adding a small amount of pitch blend and U to heated Pb, then adding PbO, and stirring the mass while cooling.

(1120) Austral. 9,856/32 (1933). C. C. Carpenter, *Producing Lead Powder.* Method comprises placing balls of Pb in a cylinder rotating with high speed, and supplying air to the cylinder to remove the Pb-dust formed by the attrition of the grinding balls.

(1121) Brit. 388,674 (1933). A.G. für Bergbau, Blei & Zinkfabrikation Zu Stollberg, *Zinc.* Production of metallic Zn from dust is accomplished in closed drums whose walls effect friction against the metal drops enclosed in oxide shells to the extent of releasing the metal; the walls are kept by external heating above the fusion temperature of Zn.

(1122) German 569,918 (1933). G. Shimadzu, *Apparatus for Producing Lead Dust.* Pb-dust is produced in a grinding drum into which hot oxidizing gases are blown, so that the oxidation occurs at 200° C. (390° F.), and the gases take away the Pb-dust.

(1123) U. S. 1,910,280 (1933). R. N. Chamberlain (Gould Storage Battery Co.), *Non-Reactive Lead Powder.* Method comprises introducing pieces of Pb within a rotating drum, maintaining the temperature of material in the drum at a point below that at which a preponderant amount of PbO and Pb_2O mixture will be formed.

(1124) Brit. 413,337 (1934). New Jersey Zinc Co., P. M. Ginder and G. F. Halfacre, *Method and Apparatus for the Manufacture of Zinc Dust.* Zn-powder is produced by condensation of Zn-vapor in a substantially gas-tight chamber under the constant gas pressure of an inert gas such as N_2.

(1125) Brit. 421,297 (1934). P. Kemp and E. Feuer, *Apparatus for Pulverizing Lead for the Formation of Oxide.* Method comprises spraying molten Pb into a rotating chamber provided with means for disintegrating the Pb, maintaining temperature by means of hot gases which act on the Pb and which contain no component reacting with it.

(1126) French 760,584 (1934). P. Kemp and E. Feuer, *Apparatus for Pulverizing Lead for the Formation of Oxide. Cf.:* Br. 421,297 (No. 1125).

(1127) French 766,939 (1934). New Jersey Zinc Co., *Zinc Dust.* Vapor of Zn is condensed to dust in a gas-tight chamber in which a constant pressure is obtained by action of an inert gas.

(1128) U. S. 1,961,065 (1934). T. A. Mitchell (L. M. Hughes), *Recovering Tin.* Granulated Sn-Fe alloy is prepared for treatment with a chloridizing agent to remove the Sn as $SnCl_2$.

(1129) U. S. 1,961,296 (1934). L. S. Ishimura, *Production of Lead Powder.* Process of making Pb-powder from lumps comprises feeding the latter through an opening to a tumbling mill and blowing air into the mill to carry the powder out of it, as soon as it is formed.

(1130) U. S. 1,994,345 (1935). P. M. Ginder and L. S. Holstein (New Jersey Zinc Co.), *Purifying Zinc Vapor.* Method comprises scrubbing vapor with molten Zn obtained by condensing part of the vapor and permitting molten Zn to flow back to volatilizing source.

(1131) U. S. 1,994,346 (1935). L. S. Holstein and P. M. Ginder (New Jersey Zinc Co.), *Apparatus for Purifying Zinc.* Apparatus comprises retort heating means, a reflux column, conduct means for introducing unvaporized Zn, and a condenser.

(1132) U. S. 1,994,347 (1935). P. M. Ginder (New Jersey Zinc Co.), *Purifying Zinc.* An apparatus for purifying Zn comprises a plurality of distillation retorts and reflux columns communicating at their lower ends with the retorts, and means permitting the flow of vapor from each retort to the lower end of its reflux column.

(1133) U. S. 1,994,348 (1935). P. M. Ginder (New Jersey Zinc Co.), *Purifying Zinc.* Zn, contaminated with Pb, is re-distilled in a continuously operated system, the Zn-vapor being conducted to a condensing system.

(1134) U. S. 1,994,349; 1,994,350; 1,994,351; 1,994,352; 1,994,353; 1,994,357 (1935). R. K. Waring, P. M. Ginder and W. M. Peirce (New Jersey Zinc Co.), *Apparatus and Method of Purifying Zinc Metal.* Zn, contaminated with lower-boiling metal, is vaporized, and the vapor passed through a decreasing temperature gradient by repeated condensation. Details of the vaporization apparatus are claimed.

(1135) U. S. 1,994,354 (1935). P. M. Ginder and H. G. Hixon (New Jersey Zinc Co.), *Method of and Apparatus for Purifying Zinc Metal.* Zn-vapor, contaminated with Pb and Cd, is purified.

(1136) U. S. 1,994,355; 1,994,356 (1935). H. M. Peirce and R. K. Waring (N. J. Zinc Co.), *Volatilizing Zinc and Apparatus for it.* A series of pools of molten Zn are heated to volatilize and withdraw the vapor.

(1137) U. S. 2,007,027 (1935). J. F. W. Schulze, (Grasselli Chemical Co.), *Apparatus and Process for the Manufacture of Zinc Dust.* Manufacture of Zn-dust comprises maintaining the gases in the condenser near to the normal operating temperature, while a retort which communicates with the condenser is not operating.

(1138) U. S. 2,007,545 (1935). H. H. Monson (American Smelting & Refining Co.), *Process for Treating Antimonial Lead.* Dry dross of 70-80% Sb, and a Sb-Pb alloy, are produced in mixed powder and particle form in recovering Sb from the Sb-Pb.

(1139) U. S. 2,011,882 (1935). R. Teats (American Smelting & Refining Co.),

Treating Sulfate Solution of Thallium. Pure flake Tl is deposited on cathodes in process for recovering Tl from Cd-Tl-sulfate solution.

(1140) U. S. S. R. 43,647 (1935). N. V. Petrov, *Zinc Dust.* 5% Al is added to fused Zn and the mixture is atomized at 300° C. (570° F.).

(1141) Austral. 22,460/35 (1936). Electrolytic Zinc Co. of Australasia, *Zinc Dust for Gold Recovery.* Method comprises producing Zn or Cd dust by supplying Zn or Cd vapor in a chamber filled with an inert gas and condensing the vapors therein, whereby the gas is circulating.

(1142) German 640,649 (1936). The New Jersey Zinc Co., *Apparatus for The Manufacture of Zinc Powder.* An apparatus for evaporating and condensing Zn-vapor is described.

(1143) U. S. 2,030,357 (1936). E. F. Doom (Union Carbide & Carbon Co.), *Process of Removing Tin from Columbium.* Sn is removed from Cb-alloys by introducing Si into the alloy, and then comminuting and leaching the alloy.

(1144) U. S. 2,060,453 (1936). R. Teats, (American Smelting & Refining Co.), *Process for Recovering Thallium.* Tl-sponge is deposited on cathodes in a process for separating Cd and Tl.

(1145) Brit. 467,058 (1937). The Alloys Co., *Zinc Dust.* Process for manufacturing of Zn dust makes use of an expansion chamber.

(1146) German 653,557 (1937). I. G. Farbenindustrie A. G., E. Büttgenbach and R. Lühdemann, *Production of Zinc Dust.* Process for the electrolytic production of Zn dust from zincate solutions comprises separation of Zn on the surface of the cathode, permanently immersed in the electrolyte, so that no part of the cathode is exposed to atmosphere.

(1147) Brit. 480,932 (1938). Metallgesellschaft A. G. and K. R. Gohre, *Treatment of Zinc Dust Containing Cadmium. Cf:* German 665,125 (No. 1149).

(1148) Canadian 373,908 (1938). M. H. Newell (Alloys Co.), *Process and Apparatus for the Manufacture of Zinc Dust. Cf:* U. S. 2,133,560 (No. 1151).

(1149) German 665,125 (1938). Metallgesellschaft A. G. and K. R. Gohre, *Treatment of Zinc Dust Containing Cadmium.* Cd-bearing Zn-dust is melted to form a Zn-Cd bearing alloy. Alloy may be treated by fractional distillation and condensation to recover Cd.

(1150) German 667,819 (1938). Siemens & Halske A. G., *Zinc Powder.* Method comprises manufacturing of Zn powder by electrolysis of aqueous solutions.

(1151) U. S. 2,133,560 (1938). M. H. Newell (Alloys Co.), *Process and Apparatus for the Manufacture of Zinc Dust.* By use of an expansion chamber into one side of which Zn-vapor is introduced from the mouth of a retort, gas is continuously blended together with entrained Zn-dust, and later separated and re-used.

(1152) Brit. 506,590 (1939). I. G. Farbenindustrie A. G., E. Büttgenbach and R. Lühdemann, *Zinc Dust. Cf:* German 653,557 (No. 1146).

(1153) French 838,166 (1939). Siemens & Halske A. G., *Zinc Powder.* Method for reducing the speed of reaction of Zn provides for very fine pulverized Pb to be added to Zn.

(1154) German 677,992 (1939). I. G. Farbenindustrie A. G., E. Büttgenbach and R. Lühdemann, *Production of Zinc Dust.* Lifting appliance for the cathodes according German 653,557 (No. 1146) consists of a releasing device for the symmetrically arranged electrodes, to produce a temporary impact to the cathodes, to free them of the Zn powder.

(1155) Japan 129,103; 129,474 (1939). Z. Kimura (Mitubisi Kogyo K.K.), *Agglomeration of Powdered Tin.* Powdered Sn is added to a molten mixture of NaOH and NaCl to collect Sn at the bottom of the vessel.

(1156) U. S. 2,145,433 (1939). H. Richter, *Recovery of Tin.* In separating Sn from alloys, the alloy to be treated is pulverized to 200-mesh size before further treatment.

(1157) French 853,543 (1940). Hüttenwerke Siegerland A. G., *Separating Zinc from Zinc Dust.* Method for separating Zn from dust comprises gathering the

molten metal in a container with a cylinder that can exercise a pressure on the metal.

(1158) Hung. 123,819 (1940). M. Weiss-Acél (R. T. Femmuvei), *Powdered Lead.* Production is accomplished by reduction of oxide.

(1159) Brit. 540,330 (1941). S. Isaki, *Composite Lead Powdered for The Electrodes of Storage Batteries.* Method of production comprises slowly dropping molten Pb into water, removing resulting Pb lumps from it, exposing them to air, and sprinkling water over them.

(1160) German 704,662 (1941). Siemens & Halske A. G., T. Meissl, M. Passer and G. Haensel, *Zinc Powder of Predetermined Diminished Reactivity.* Reactivity of Zn powder, used as a reducing agent, can be regulated by precipitating it cathodically together with 0.1-0.7% Pb, Hg, Ag, Bi, or Sb, having the same particle fineness as the Zn.

(1161) U. S. 2,237,043 (1941). H. D. Wilson (Presto-Lite Storage Battery Corp.), *Method of Manufacturing Oxidized Lead Powder.* Small streams of water are applied to the surface of masses of Pb above 100° C. (212° F.).

(1162) U. S. 2,253,632 (1941). Y. E. Lebedeff (American Smelting & Refining Co.), *Finely Divided Lead.* Process of producing finely divided Pb comprises incorporating stearic acid in the molten metal containing Ca and Mn at 370° C. (700° F.) until dross is produced.

(1163) German 718,170 (1942). Alexander Wacker Ges. für Elektrotechnische Industrie and F. X. Schwaebel, *Method for the Production of Copper Bearing Lead Powder.* Method comprises agitating inorganic Cu salts and Pb powder in presence of an auxiliary metal, *e.g.* Zn, by a violent motion of the fluid during the reaction, so that the Pb powder and the Zn powder will not touch each other.

(1164) German 720,663 (1942). Siemens & Halske A. G., W. Wolf, and G. Haensel, *Powdered Zinc.* Preparation by electrolysis of Zn salts (not necessarily pure) in aqueous solution provides for a cathodic current density of 900-1000 amps. per sq. m., and a bath temperature somewhat raised.

(1165) German 727,689 (1942). I. G. Farbenindustrie A. G. and E. Podszus, *Powdered Antimony.* Aqueous solutions of complex salts of $SbCl_3$ are treated with alkali and/or alkaline earth halides and a metal that is less noble than Sb.

(1166) U. S. 2,271,970 (1942). H. M. Doran and A. J. Alf (Anaconda Copper Mining Co.), *Recovery of Indium.* In is precipitated in sponge form, easily removed from the precipitant, by using metallic Al as precipitant.

(1167) German 735,221 (1943). Siemens & Halske A. G., T. Meissl, M. Passer, and G. Haensel, *Zinc Powder of Predetermined Diminished Reactivity.* Improvement of the method of German 704,662 (No. 1160) provides for constantly feeding the electrolyte with Pb in form of a solution, to diminish equally the velocity of the reaction of the Zn.

(1168) U. S. 2,313,338 (1943). W.H. Hannay (Consolidated Mining & Smelting Co.), *Depositing of Sponge Zinc.* Method comprises electrolyzing neutral $ZnSO_4$ solution and maintaining the neutrality and concentration of the electrolyte by adding ZnO and NH_4HSO_4.

(1169) U. S. 2,331,395 (1943). W. Holmes (Sunshine Mining Co.), *Electrolytic Recovery of Antimony.* Electrolytic recovery of metals, such as Sb, from tetrahedrite concentrate is claimed.

(1170) U. S. 2,332,403 (1943). J. A. Smail (Republic Steel Corp.), *Recovery of Zinc Dust.* Recovery of Zn dust from by-products of galvanizing operations is claimed.

(1171) U. S. 2,341,805 (1944). W. A. Ogg, *Recovery of Zinc.* Recovery of Zn is accomplished by indirect heating in a retort a mixture of ZnO, carbonaceous materials and powdered Si.

(1172) U. S. 2,342,368 (1944). A.L.J. Queneau, *Zinc Metallurgy.* Flash reduction operation by means of a carboniferous reducing agent is used for producing Zn from zinciferous oxide material.

(1173) U. S. 2,342,733 (1944). L. J. Guyard, *Method for Purifying Bismuth.* Pulverized Bi alloy is treated with HNO_3.

(1174) U. S. 2,348,194 (1944). R. G. Crane and M. F. Perkins (American Smelting & Refining Co.), *Metallic Zinc Vapor Condensation.* Method comprises condensing of Zn-vapors formed by reducing zinciferous substances.

(1175) Brit. 576,906 (1946). The National Smelting Co. Ltd., *Zinc Dust.* Zn-dust is produced from gas containing a small proportion of Zn vapor and CO_2 by shock-chilling a stream of gas to a temperature below the solidification point of Zn.

(1176) Brit. 590,917 (1947). Ford Motor Co. Ltd., *Magnesium.* Mg vapor from electrothermic reduction of oxide is quenched in an oil spray to produce solid Mg in fine suspension.

(1177) Brit. Appl. 4422/47 (1947). Soc. Miniere et Métallurgie de Penarroya, *Production of Spherical Granules of Lead.* Method provides shotting molten Pb in absence of As but in a butane atmosphere under slight pressure.

(1178) U. S. S. R. 68,440 (1947). A. T. Nizhnik, *Recovery of Indium from Zinc Production Waste.* Blue powder is leached with H_2SO_4 in presence of NaCl, until all Cd is dissolved; the solution is treated with Zn in presence of NaCl to precipitate In in form of a sponge.

(1179) U. S. 2,413,762 (1947). G. Gutzeit, E. J. Roberts and R. B. Thompson (Dorr Co.), *Tin Ore Treatment.* Method comprises heating the ore during a controlled time above 550° C. (1020° F.) and below 800° C. (1470° F.) in a reducing atmosphere in presence of S, so that SnS and Sn are formed, whereby the Fe in the final product is in form of a sulfide and stable at the reaction temperature.

(1180) U. S. 2,429,668 (1947). H. S. Cooper (Acme Aluminum Alloys Inc.), *Furnace for Reduction and Vacuum Distillation of Magnesium Oxide.* Furnace for reduction of MgO by $CaSi_2$ and subsequent vacuum distillation and condensation of vaporized metal is claimed.

(1181) U. S. 2,433,615 (1947). G. T. Mahler (New Jersey Zinc Co.), *Treatment of Dross for Recovery of Zinc.* Method of recovering Zn from dross comprises introducing dross at the top of a packed column externally heated to maintain the melting zone near its top, and the volatilizing zone below the melting zone.

(1182) U. S. 2,433,770 (1947). Y. E. Lebedeff (American Smelting & Refining Co.), *Process of Recovering Indium.* Process for separating In from In-containing Pb comprises a molten bath, a chloridizing agent, and stirring the slag into the melt to cause the In to react.

(1183) U. S. 2,454,142 (1948). J. T. Ellsworth, *Electrolytic Recovery of Zinc.* Improvement of U. S. 1,429,330 (No. 1093) comprises reducing the concentration in the solution of soluble salts which have a harmful effect during the electrodeposition, to a substantial dryness of 3-10%, making the harmful salts insoluble without impairing the solubility of Zn.

(1184) U. S. 2,457,544; 2,457,545; 2,457,546; 2,457,547; 2,457,548; 2,457,549 (1948). E. C. Handwerk, G. T. Mahler and H. C. Haupt (New Jersey Zinc Co.), *Condensing Zinc Vapors.* Method comprises passing Zn vapors through a condensing chamber with molten Zn which is hurled by rotating discs and centrifugal action, to cause an upward directed shower of the molten metal, through which the Zn-vapors pass.

(1185) U. S. 2,457,550 (1948). E. C. Handwerk, G. T. Mahler and H. C. Haupt (New Jersey Zinc Co.), *Condensing Zinc Vapors.* Method comprises maintaining molten Zn in the condensing chamber, raising it vertically and throwing it outward in form of an umbrella-like shower, through which the Zn-vapors pass.

(1186) U. S. 2,457,551; 2,457,553 (1948). E. C. Handwerk, G. T. Mahler and H. C. Haupt (New Jersey Zinc Co.), *Condensing Zinc Vapors.* An apparatus is claimed wherein in the first zone the temperature of the condensing surface is high enough to prevent the formation of blue powder, effecting in the second zone the condensation of previously uncondensed Zn vapors by a shower of molten Zn.

(1187) U. S. 2,457,552 (1948). E. C. Handwerk, G. T. Mahler and H. C. Haupt (New Jersey Zinc Co.), *Vertical Retort for Zinc Melting.* Method comprises heating the top of the column with the agglomerated charge to inhibit the condensation of Zn vapors and the reflux of molten Zn, and a condensing chamber outside the column.

(1188) Brit. Appl. 32850/49 (1949). Erzhütte A. G., *Process for Simultaneous Recovery of Base Metal Powder and of Metallic Salts.* Sb powder is obtained by treating moist ore with excess of Na-amalgam, whereby Na_2S may be recovered as secondary product. Hg is reconverted into the amalgam by electrolysis of sodium chloride.

(1189) U. S. 2,464,262 (1949). S. R. Clifton (National Smelting Co. Ltd.), *Production of Zinc.* An improved process is disclosed for condensing Zn vapor from a gaseous mixture.

(1190) U. S. 2,473,304 (1949). S. R. Redland (The National Smelting Co. Ltd.), *Condensation of Zinc from its Vapor in Gaseous Mixtures.* Formation of blue powder in retort smelting of ZnO is minimized by the process. Gas-Zn vapor mixture is fed with minimum heat loss to a first condensing stage, where it is contacted with a shower of molten Zn metal at tapping temperature.

(1191) U. S. 2,473,611 (1949). S. R. Redland (The National Smelting Co. Ltd.), *Process for the Production of Zinc.* A process is claimed for producing metallic Zn from Zn-vapors obtained from roasted ores, slags and other zinciferous materials.

(1192) U. S. 2,473,962 (1949). F. G. McCutcheon (The Eagle-Picher Co.), *Process for Recovering Cadmium.* A process is disclosed for recovering Cd and small amounts of Pb, Cu, Ge and In from the metallurgical dust recovered from the Cottrell precipitator in Zn smelting operations.

(1193) U. S. 2,474,979 (1949). J. F. Jordan, *Process for the Extraction of Tin from Iron Alloys.* A Sn-Fe alloy is molten and poured into water so as to subdivide the alloy in a manner that comminutes the cross-section of the individual alloy particles; after treating the powdered alloy with H_2, it is then treated with a molten flux that is capable of removing films from the particle surfaces; the powdered alloy is then treated with molten Pb, and the Sn is finally extracted.

(1194) U. S. 2,475,607 (1949). P. W. Garbo (The American Metal Co., Ltd.), *Fluidization in Zinc Production.* The improvement of this invention comprises condensing the Zn vapor contained in the gaseous effluent withdrawn from the reduction zone and using a portion of the condensed Zn as a fluidizing medium in the reduction zone.

(1195) U. S. 2,477,799 (1949). J. L. Hart (American Smelting & Refining Co.), *Process for Separating Indium from Contaminants.* The In may be separated as a powder by dissolving it in an acid solution, purifying the resulting solution by reacting the acid solution with $Na_2S_2O_4$, thereby rendering such contaminants as Cu, As, Se, and Te amenable to removal by filtration.

(1196) U. S. 2,478,594 (1949). A. L. J. Queneau, *Method of Condensing Zinc.* The gases and vapors are maintained under sufficient pressure to force the molten Zn upward and to force gases and vapors from which the Zn is condensed through the mechanism and through the remaining molten metal. Gases are removed and ZnO and blue powder residues are drawn from the condenser.

(1197) U. S. 2,478,912 (1949). P. W. Garbo (The American Metal Co., Ltd.), *Fluidizing Process for Zinc Recovery.* ZnO and powdered coke are introduced into the fluidized mass and reduction is effected therein at 870–1260° C. (1600-2300° F.). Fe-containing agglomerates are removed from the bottom and Zn is recovered in powder form from the gaseous effluent of the fluidized mass.

(1198) U. S. 2,485,604 (1949). J. C. Kalbach (The American Metal Co. Ltd.), *Fluidizing Process for Producing Zinc.* A comminuted solid material containing ZnO is introduced with comminuted coke as reducing agent into a fluidized bed of the solids.

vi. Light Metals (Aluminum, Magnesium, Beryllium)

(1199) U. S. 324,659 (1885). E. Cowles, *Process for Electric Smelting.* Al is produced as an amorphous powder by reduction of ore with Sn, Cu, Mn, etc., followed by separating the alloying metal from the Al by amalgamation, etc.

(1200) Brit. 15,959/1895 (1895). Aluminium Industrie A. G. and W. L. Wise, *Production of Granulated Aluminum and Magnesium.* Method comprises heating the metal to a temperature at which it loses its cohesion, without melting, and then subjecting it at the same temperature to stamping or grinding.

(1201) German 113,596 (1900). Bronzefarbenwerke A. G., *Producing Aluminum Powder.* Molten Al is poured into water, and the resulting metal lumps are then crushed to powder.

(1202) U. S. 1,311,378; 1,311,379 (1919). W. F. Bleecker and W. L. Morrison (Electric Reduction Co.), *Apparatus for Producing Alkali-Earth Metals, such as Magnesium.* Mg is condensed in liquid or solid form from Mg-vapor.

(1203) U. S. 1,311,380 (1919). W. F. Bleecker and W. L. Morrison (Electric Reduction Co.), *Alkali Earth Metal.* Amorphous metallic Mg powder of nodular form is produced by mixing calcinated magnesite in crushed form with crushed Si or metallic Al as a reducing agent; then MgO or CaO is added, to promote fluidity, and the mixture is fused in an electric furnace.

(1204) U. S. 1,327,743 (1920). L. B. Tebbets, *Process of Making Powdered or Granulated Aluminum.* Method comprises heating the metal to a temperature above the melting point, agitating and pulverizing it by reducing the temperature until the metal is solidified.

(1205) U. S. 1,351,865 (1920). D. S. Nicol (Shawinigan Electro-Metals Co.), *Process for the Manufacture of Magnesium Powder.* Method comprises melting Mg in atmosphere of gas and discharging molten Mg into a N_2-atmosphere, by which process Mg is disintegrated into fine particles.

(1206) U. S. 1,356,780 (1920). D.S. Nicol (American Magnesium Corp.), *Apparatus for the Manufacture of Magnesium Powder.* A jet of a fluid (gas) of high velocity is projected against molten metal emerging from a crucible, and the resulting disintegrated metal is received by a removable cup.

(1207) German 361,408 (1922). A. Pacz, *Method of Producing Powdered Aluminum.* It comprises mixing Al with Si to become brittle, casting into a shape, cutting and crushing.

(1208) French 716,707 (1931). Hartstoff-Metall A. G., *Aluminum Powder.* Method of producing Al-powder in an inert atmosphere comprises adding small quantities (1-3%) of H_2 and steam to the atmosphere.

(1209) Brit. 362,835 (1932). Österreichisch-Amerikanische Magnesit A. G., *Process for Production of Metallic Magnesium.* Electrothermic production of Mg comprises reduction of Mg compounds with C in a current of inert gas; the metal vapors are condensed to dust and the dust is converted into compact metal by heating.

(1210) French 719,287 (1932). Österreichisch-Amerikanische Magnesit A. G., *Magnesium Dust.* Dust of Mg in an inert atmosphere is heated to a temperature somewhat below the point of ebullition to produce agglomeration of particles.

(1211) U. S. 1,884,993 (1932). F. Hansgirg, *Production of Metallic Magnesium.* Mg-containing material and carbonaceous reducing material are subjected to a heating zone to produce Mg vapors which are diluted and chilled suddenly at their point of discharge by contact with a non-oxidizing gas.

(1212) French 733,294; 44,064 (Add.) (1932). G. Gire and R. Fouquet, *Magnesium.* Manufacture of Mg consists of heating MgO with a material for reduction such as Si, vaporizing and condensing.

(1213) Brit. 406,958 (1934). Österreichisch-Amerikanische Magnesit A. G., *Process for Production of Metallic Magnesium.* In this addition to Brit. 362,835 (No. 1209) the distillation of the Mg occurs under increased pressure.

(1214) French 44,141 (Add.) (1934). Österreichisch-Amerikanische Magnesit A. G., *Magnesium Dust.* In this addition to French 719,287 (No. 1210) the distillation of the Mg occurs under increased pressure.

(1215) U. S. 1,964,853 (1934). F. R. Kemmer (Magnesium Products Inc.), *Method of Treating Light Metal Powder.* Mg-powder is treated by mixing with other material capable of protecting the Mg by combining with deleterious substances, by subjecting it to a temperature above the melting point and below the boiling point of Mg, and to a rubbing action to cause the Mg to coalesce.

(1216) Brit. 435,234 (1935). Österreichisch-Amerikanische Magnesit A. G., *Production of Metallic Magnesium.* Mg dust is wetted with hydrocarbon oils, and the mixture is then freed of the hydrocarbon by heating, whereafter the metal is extracted from the solidified residual mass.

(1217) French 789,970 (1935). Österreichisch-Amerikanische Magnesit A. G., *Magnesium Dust.* Distillation of Mg occurs in an electric furnace in which the material is switched in-between the poles.

(1218) German 608,613 (1935). I. G. Farbenindustrie A. G., *Production of Magnesium Powder.* The crushing of the solid metal occurs with the aid of needles of steel, which are incorporated in circulating bands.

(1219) German 619,624 (1935). Hartstoff Metall A. G., *Aluminum Powder.* Al powder is manufactured by the grinding process in an inert atmosphere with the addition of 1-3% O_2 for the production of a protective layer on the powdered particles to prevent explosions.

(1220) Austrian 147,462 (1936). American Magnesium Metals Corp., *Conversion of Magnesium Dust into Compact Metallic Magnesium. Cf:* U. S. 2,097,689 (No. 1225).

(1221) U. S. 2,040,804 (1936). J. E. Bucher (Antioch Industrial Research Institute, Inc.), *Recovery of Beryllium.* Spangles of finely divided Be powder are produced by using an alkali salt of weak acid to dissolve BeOH and purify Be.

(1222) Austrian 150,276 (1937). Österreichisch-Amerikanische Magnesit A. G., *Method of Forming Compacts of Magnesium.* Mg is produced from dust by wetting the dust with oil of carburetted H_2 gas, heating the mixture to the cracking temperature of the oil and then heating the agglomerate to the boiling point of the metal to separate it by condensation.

(1223) U. S. 2,074,726 (1937). F. Hansgirg (American Magnesium Metals Corp.), *Process for the Production of Light Metals by Smelting Compounds Thereof.* Detached uniformly small compact bodies are formed from a mixture of a reducible Mg compound and a solid reducing agent, dropped one by one to a body of non-metallic resistance material loosely heaped on the bottom of an electric furnace and directly heated to above the boiling point of Mg to liberate and vaporize the Mg content of each detached body, followed by passing the Mg-vapor into a condenser and cooling it to the condensation point.

(1224) U. S. 2,088,165 (1937). K. Erdmann (American Magnesium Metals Corp.), *Production of Light Metals.* A mixture of a reducible compound of Mg, a carbonaceous reducing agent, and a freely carbonizing binding agent is formed into compact bodies, which are introduced in a non-baked state into a reduction chamber maintained by electric heating at temperature above the boiling point of Mg to liberate Mg-vapor which is then condensed.

(1225) U. S. 2,097,689 (1937). K. Erdmann and F. Hansgirg (American Magnesium Metals Corp.), *Conversion of Magnesium Dust into Compact Metallic Magnesium.* Method comprises mixing Mg dust with a current conducting substance indifferent to the metal, which at the temperature of vaporization of Mg remains solid.

(1226) German 663,737 (1938). Österreichisch-Amerikanische Magnesit A. G., *Method of Forming Compacts of Magnesium. Cf:* Aust. 150,276 (No. 1222).

(1227) U. S. 2,226,525 (1940). J. C. Hartley and P. M. Dolan, *Method and Apparatus for Reducing Chemicals, such as Beryllium.* An oxidized Be-compound is reduced in atomic H, by exposing a body of the compound to an atmosphere of H_2 in which, after removal of water and oxygen from the H_2 and from the body, an arc to dissociate molecular H_2 into atomic H is established for recovering the metallic Be from all vapors.

(1228) French 864,661 (1941). Minami Mansku Tetsudo Kabushiki Kaisha, *Magnesium Production.* Mg ores are treated with F compounds, then the MgF_2 powder is treated with CaC_2 and reduced at 1000° C. (1830° F.); the Mg precipitate is heated to remove the volatiles.

(1229) German 705,645 (1941). I. G. Farbenindustrie A. G. and H. von Zeppelin, *Beryllium.* $BeCl_2$ is mixed with Mg and a salt which lowers the fusion temperature; the whole is preferrably pressed and gradually heated to 730-900° C. (1340-1650° F.) in an atmosphere of H_2; the crystalline Be is separated from the fused mass upon cooling.

(1230) Belgian 444,907 (1942). S. A. Italiana Per Il Magnesio E Leghe Di Magnesio, *Method for Extraction of Magnesium.* The vapors of Mg are contacted with a very highly cooled surface at the end of the reaction chamber, or connected with the chamber.

(1231) German 718,122 (1942). Georg Benda-Lutz Werke and F. Lutz, *Granulated Aluminum.* A sheet of Al foil is fed tangentially into a beater where it is granulated.

(1232) U. S. 2,302,981 (1942). M. Stern, *Method for Manufacturing of Aluminum.* Al powder is produced by passing comminuted Al scrap through successive heating zones which causes brittleness and ready fragmentation of the scrap.

(1233) Canadian 415,252 (1943). H. A. Doerner, *Metallic Magnesium. Cf:* U.S. 2,328,202 (No. 1234).

(1234) U. S. 2,328,202 (1943). H. A. Doerner, *Metallic Magnesium.* Apparatus for thermal reduction of a mixture of MgO and C, and condensing the Mg, is described.

(1235) U. S. 2,328,479 (1943). F. Mathieu, *Electrical Oven for High Temperatures, Suited for Recovery of Magnesium.* Recovery of metals such as Mg by thermal reduction is performed in an electric furnace under vacuum or neutral gas.

(1236) U. S. 2,330,724 (1943). R. McCarroll (Ford Motor Co.), *Method of Magnesium Production.* Metallic Mg is produced by reducing MgO with C.

(1237) U. S. 2,330,751 (1943). F. G. Shaub, R. McCloud, and B. E. Tiffany (Ford Motor Co.), *Reduction Apparatus.* In producing Mg powder, MgO is reduced with finely divided C.

(1238) U. S. 2,334,258 (1943). F. J. Gavin (Crown Cork & Seal Co.), *Forming Powders of Metals Such as Aluminum.* The metal is ground in the presence of a lubricant, dried and polished in the presence of a leafing agent.

(1239) U. S. 2,334,451 (1943). E. C. Spooner (Anglo California National Bank), *Manufacture of Metallic Magnesium.* Mg in powder form is produced by carbothermic reduction of MgO.

(1240) Brit. 562,469 (1944). F. W. Berk & Co., Ltd. and C. G. Six, *Light Metal Powders.* A molten light metal is subjected to the action of a jet of an aqueous medium which breaks it up into particles. The aqueous medium contains a water soluble chromate, phosphate, silicate or tungstate.

(1241) U. S. 2,349,408; 2,349,409 (1944). H. P. Davis, *Production of Magnesium.* Apparatus is claimed for producing metallic Mg by reduction of MgO-containing raw material.

(1242) U. S. 2,349,556 (1944). W. R. Kleckner (J. A. McCarthy Co.), *Treating Magnesium Minerals.* Mg in powder form is produced from Mg minerals containing Fe.

(1243) U. S. 2,349,927 (1944). T. Arimori, *Producing Metallic Magnesium.* Method comprises manufacturing metallic Mg from MgO-containing ores by reduction, vaporization and condensation.

(1244) U. S. 2,353,193 (1944). R. Sayers (Secretary of the Interior of U. S.), *Recovery of Metallic Magnesium.* Mg in powder form is produced by reduction and volatilization utilizing He as condensing agent.

(1245) U. S. 2,354,253 (1944). H. Gentil, *Reduction of Magnesium.* Mg is produced directly from its compounds with O, using Al or Ca as reducing agent.

(1246) U. S. 2,357,614 (1944). T. Stowell (St. Joseph Lead Co.), *Treating Finely Divided Magnesium.* Method comprises consolidating finely divided solid metallic Mg by treating it with a metal, having a lower boiling point than Mg, at a temperature above the melting point of the treating metal, and thereafter separating the Mg from the metal.

(1247) U. S. 2,364,195 (1944). W. A. Darrah, *Process of Magnesium Production.* Method for producing Mg comprises removal of CO_2 from $MgCO_3$ in the treating furnace, using a non-carbonaceous reducing agent.

(1248) Brit. 573,149 (1945). W. E. Prytherch, *Magnesium Production.* Mg is produced by thermal reduction, using solid reducing agents to prevent Mg losses by secondary reactions. For example, MgO, CaC_2, and ferrosilicon are mixed in proportion of 6:3:2, briquetted, and heated *in vacuo*, to obtain a 54.5% Mg yield.

(1249) U. S. 2,370,812 (1945). L. M. Pidgeon (Dominion Magnesium Ltd.), *Apparatus for Producing Magnesium.* Thermal production of Mg by ferrosilicon reduction under reduced pressure is claimed.

(1250) U. S. 2,370,898 (1945). L. V. Whiton (Dominion Magnesium, Ltd.), *Production of Metallic Magnesium.* Producing metallic Mg powder by thermal reduction of MgO-containing materials with ferrosilicon is claimed.

(1251) U. S. 2,372,571 (1945). F. Hansgirg (North Carolina Magnesium Development Co.), *Process for Manufacturing Metallic Magnesium.* Metallic Mg is produced by direct reduction of $MgSiO_3$. Fe-Cr-Ti alloys in granular form are obtained as a byproduct.

(1252) U. S. 2,373,320 (1945). W. G. Lovell (General Motors Corp.), *Production of Aluminum.* Al is electrolytically produced in powdered form from $AlBr_3$ solution, using a vibrating cathode.

(1253) U. S. 2,376,535 (1945). H. F. Fisher (Union Oil Co. of California and The Anglo-California National Bank), *Removal of Oils from Powdered Magnesium.* Finely divided Mg powder, formed when chilling Mg vapors, is separated from hydrocarbon oils by means of an electrostatic drum separator.

(1254) U. S. 2,377,478 (1945). W. S. Bowen, *Process for Manufacturing Metallic Magnesium.* Method and furnace for producing metallic Mg from Mg-containing compounds, by vaporizing the reduced metal and chilling it suddenly to freeze it into a powdered form, is disclosed.

(1255) U. S. 2,379,576 (1945). F. Hansgirg (North Carolina Magnesium Development Co.), *Process for Manufacturing Metallic Magnesium.* Producing metallic Mg comprises direct reduction of $MgSiO_3$ using powdered ferrosilicon.

(1256) U. S. 2,380,449 (1945). R. C. Kirk (Dow Chemical Co.), *Production of Magnesium.* Metallic Mg is produced by reduction and vaporization of MgO with C.

(1257) U. S. 2,382,432 (1945). C. E. McManus (Crown Cork & Seal Co.), *Method for Depositing Vaporized Aluminum Powder.* Al powder is prepared by depositing vaporized Al on a non-retentive surface.

(1258) U. S. 2,382,713 (1945). F. Hansgirg (Marine Magnesium Products Corp.), *Process for Manufacturing Magnesium.* Method comprises thermal reduction of solid phase MgO with solid phase CaC_2.

(1259) U. S. 2,384,008; 2,384,009; 2,384,010 (1945). H. R. Brandenburg (Idaho Maryland Mines Corp.), *Magnesium.* Methods for converting hydrous $MgSiO_3$ into basic products, for recovering Mg from salts, and for producing $MgSO_4$ are disclosed.

(1260) U. S. 2,387,979 (1945). H. S. Cooper (Acme Aluminum Alloys Inc.), *Method of Reducing Magnesium Oxide.* Finely divided MgO mixed with finely divided $CaSi_2$ are heated to produce metallic Mg powder.

(1261) U. S. 2,391,193 (1945). J. C. Rademaker, *Process for the Production of Magnesium.* Method of producing metallic Mg by reduction of MgO-containing raw material comprises forming a reaction mixture of the initial material and a reducing agent, heating under vacuum to cause Mg vapor to be given off, and cooling the vapor below solidification point of the Mg.

(1262) U. S. 2,393,704 (1946). H. Ogorzaly (Standard Oil Development Co.), *Process for Producing Magnesium.* Powdered ores of Zn and Mg are reduced by heating them with finely divided C to produce the metals.

(1263) U. S. 2,394,052 (1946). H. E. Hall and A. F. Knoll (Metals Disintegrating Co.), *Method of Manufacturing Magnesium Powder.* Method of producing comminuted metal of such chemical characteristics and particle size that when dusting occurs there is danger of explosion, consists in subjecting the massive metal to the action of a disintegrator, protecting the produced particles by a volatile liquid coolant, and later removing the coolant.

(1264) U. S. 2,396,658 (1946). S. E. Hybinette and F. C. Cary, *Process of Producing Mg and Other Metals.* Production of metals by the thermal reduction of $MgSiO_3$ ores is claimed.

(1265) U. S. 2,398,443 (1946). J. C. Munday (Standard Oil Development Co.), *Production of Light Metals.* Production of Mg powder from Mg ores by reduction is claimed.

(1266) U. S. 2,399,096 (1946). A. C. Byrns (Permanente Metals Corp.), *Production of Magnesium.* Production of Mg-containing mixtures is claimed for use in the preparation of the metal by reduction.

(1267) U. S. 2,400,000 (1946). D. Gardner (Gardner Thermal Corp.), *Production of Aluminum Powder.* Continuous thermal process for the industrial production of Al from its oxides in finely divided form is carried out by a sequence of heat treatments during progressive advance of the oxide mass in non-oxidizing atmosphere and at rising temperatures, whereby intermediate compounds are produced, whose reduction yields Al.

(1268) U. S. 2,405,662 (1946). C. E. McManus (Crown Cork & Seal Co.), *Aluminum Powder by Deposition of a Metallic Coating.* Al powder is produced by condensing Al vapor on an endless belt, detaching the film formed, and ball-milling and screening the film to produce powder.

(1269) Brit. Appl. 14804/47 (1947). American Electro Metal Corp., *Producing Magnesium Powder.* A stream of Mg vapor containing H_2 is taken off to a cyclone, with a cooled branch supply of H_2 being admitted at a point at which the gases are still at furnace temperature; the mixed carrier and cooling gases are returned from the cyclone to the rotary blower and the powder removed from the cyclone. The powder is transferred to drums and stored in inert atmosphere.

(1270) Brit. 606,637; 606,644 (1948). Honorary Advisory Council for Scientific and Industrial Research, *Ferrosilicon Process of Magnesium Production.* The briquettes of dolomite are degassed in oxidizing atmosphere; the reduction takes place at 1150-1200° C. (2100-2190° F.), and Mg is distilled in vacuo, with a dense dendritic structure of the particles obtained by condensation.

(1271) U. S. 2,437,815 (1948). F. J. Hansgirg (Permanente Metals Corp.), *Magnesium Production.* Reduction of MgO by C, produces a mixture of Mg vapor and CO; the vapor is condensed to solid Mg powder.

(1272) U. S. 2,448,243 (1948). H. P. Anderson (Permanente Metals Corp.), *Producing Magnesium Powder.* Crystalline Mg is cold rolled and embrittled by mechanically extending the crystals along the axis, then disintegrated by hammering or grinding.

(1273) U. S. 2,462,661 (1949). J. C. Munday (Standard Oil Development Co.), *Fluidization Process for Producing Aluminum.* A process for producing Al involves continuously passing a fluidized mixture of Al_2O_3 and C through a reduction zone wherein a reducing temperature is maintained and Al is vaporized. The effluent vapor product containing the reduced Al and CO is rapidly chilled by the addition thereto of a coolant consisting of fluidized Al_2O_3, and Al metal in form of a powder results.

(1274) U. S. 2,477,412 (1949). F. Lohse (Permanente Metals Corp.), *Preparation of Furnace Feed.* Process comprises intergrinding MgO and a solid reducing agent, nodulizing the intergrind while spraying it with a liquid binding agent made of asphalt dissolved in a liquid hydrocarbon and drying the formed nodules. The solid reducing agent may be coke, coal, graphite or carbon. Mg powder results.

(1275) U. S. 2,477,420 (1949). D. A. Rhoades (Permanente Metals Corp.), *Apparatus for Cooling Gaseous Media by Interchange of Heat with Cooling Gases.* In this thermal reduction of MgO with C, the Mg metal is condensed in the form of finely divided dust by means of "shock chilling", by admixing an economical quantity of cooling gas turbulently with the vapor gas mixture to be chilled without undue restriction to the flow of the gaseous reduction products from the furnace.

(1276) U. S. 2,486,475 (1949). H. C. Kawecki (The Beryllium Corp.), *Method of Producing Metallic Beryllium and Alloys of Beryllium.* A molten bath consisting of a mixture of BeF_2 and CaF_2 to which Mg is added as reducing agent is agitated throughout the reducing reaction with the resulting production of finely divided metallic Be suspended in a molten bath composed essentially of MgF_2 and CaF_2, from which the metallic Be is finally recovered.

B. Alloy Powders

i. Refractory and Precious Metal Alloys (Tungsten-Molybdenum, Tungsten-Tantalum, Stellites)

(1277) Brit. 3114/1857 (1857). R. Oxland, *Manufacture of Alloys Containing Tungsten.* By exposing powdered W ore to strong heat in a charcoal-lined crucible, W alloys in powdered form are manufactured.

(1278) U. S. 912,246 (1909). H. Kuzel, *Alloys.* Manufacture of refractory metal alloys comprising metal powders by precipitation from a colloidal solution of W mixed with a dilute solution of $PtCl_2$ and caustic soda.

(1279) U. S. 1,235,969 (1917). H. Goldschmidt and O. Weil, *Formation of High-Percentage Tungsten Alloy.* The alloy is formed by aluminothermic reaction of a mixture of a large quantity of flux, a W compound, the oxide of the alloying metal, and a reducing metal.

(1280) Brit. 279,274 (1927). Kemet Laboratories Co., *Thorium and Thorium-Tungsten.* Process of alloying Th with W consists of preparing an intimate mixture of the hydride of Th with W, subjecting the mixture to a temperature sufficient to decompose the hydride, and further heating it until complete formation of the alloy has taken place.

(1281) U. S. 1,741,953 (1929). J. H. Ramage (Westinghouse Lamp Co.), *Tungsten-Tantalum Alloy.* The W-Ta alloy is formed by treating mixtures of their oxides.

(1282) U. S. 1,759,454 (1930). J. A. Heany (Arcturus Radio Tube Co.), *Uranium Metal Alloy.* The alloy is produced by mixing 3% of powdered UO_2 and Mo, pressing the mixture into a solid slug, and positioning it between the electrodes of a furnace, for heating the mixture to cause the reduction of the oxide.

(1283) U. S. 1,896,643 (1933). H. Petersson, *Tungsten Alloys.* W-alloys are produced by mixing and heat treatment of WC and metal oxides.

(1284) U. S. 2,476,222 (1949). E. C. Rhodes (The International Nickel Co., Inc.), *Production of Powdered Metal Mixtures for Sintering.* Invention relates to the production of alloys containing one or more metals of the Pt-group, and in particular to the production of such alloys of precisely predetermined composition; in a preferred form, such as a sponge, the alloy may be reduced to a fine powder by attrition or other means.

ii. Ferrous Alloys (Carbon Steels, Alloy Steels, Iron-Nickel, Iron-Cobalt, Ferroalloys)

(1285) U. S. 1,040,699 (1912). W. D. Edmonds and I. Ladoff, *Alloy and Process of Producing Same.* Alloy of Fe and Ti is made by heating their oxides in reducing atmosphere to reduce without melting.

(1286) U. S. 1,081,567; 1,081,568 (1913). F. M. Becket (Electro Metallurgical Co.), *Method of Preparing Tungsten Alloy.* Finely divided commercially pure ferrotungsten is made by oxidizing and reducing the crude ferroalloy.

(1287) U. S. 1,153,594 (1915). F. M. Becket (Electro Metallurgical Co.), *Treatment of Tungsten Ore.* Method of preparing ferrotungsten from ores low in P consists in mixing therewith an ore of the Fe-tungstate type and smelting mixture to yield an alloy low in P.

(1288) U. S. 1,429,272 (1922). F. M. Becket (Electro Metallurgical Co.), *Purifying Tin-Bearing Ferrotungsten.* Method consists in reacting the comminuted alloy with an acid solvent for Sn.

(1289) U. S. 1,437,271 (1922). J. S. Murdoch and J. Merson, *Manufacture of Ferrotungsten.* Method comprises silicothermic reduction without aid of Al of Fe oxides and W oxides in presence of $NaNO_3$.

(1290) German 544,302 (1927). F. Pfleumer, *Steel Powder.* Method of producing finely divided steel powder comprises hardening by cementation and chilling, and granulation by milling.

(1291) U. S. 1,669,649 (1928). C. P. Beath and H. M. E. Heinicke (Western Electric Co.), *Powdered Magnetic Alloy for Cores.* Fe and Ni are heated in presence of an oxidizing agent at a temperature sufficient to cause complete fusion between the elements, in order to render the alloy brittle and readily friable into powder.

(1292) Brit. 327,419 (1930). A. F. B. Norwood and J. C. Chaston (Standard Telephones & Cables Ltd.), *Metal Alloy Dust.* An alloy of 80% Ni and 20% Fe is rendered brittle, ground, annealed at 100° C. (212° F.) and reground to produce dust for magnetic cores.

(1293) Brit. 340,762 (1931). Hartstoff-Metall A. G., *Iron Alloy.* Manufacture of Fe-alloy powder for magnetic purposes comprises forming the alloy, which has been cooled from the molten state, into small particles of a size larger than the particles of the finished powder, then raising their temperature to red heat in an inert atmosphere, and thereafter pulverizing them to the desired fineness.

(1294) French 721,987 (1931). I. G. Farbenindustrie A. G., *Ferrous Alloys.* Metal of the Fe-group reacts at higher temperature with a chloride of another metal.

(1295) Brit. 374,560 (1932). I. G. Farbenindustrie A. G., *Powders for Sintered Alloys.* Fe, Ni, and Co powders are treated with a chloride of Cr, Mn, Zn, Cu, Ti, Mo or W at 900° C. (1650° F.) in reducing or inert gas to form the alloy in powder form.

(1296) German 619,749 (1935). Heraeus-Vacuumschmelze A. G., *Production of Nickel-Iron Powder for Magnets.* Method comprises reduction of Ni-Fe crystals which are precipitated from salt solutions. The permeability of the powder is greater than that of powders produced by melting and milling.

(1297) Brit. 454,206 (1936). H. Vogt, *Production of Magnetic Powder.* A mixture of Fe and Si and/or Al is heated *in vacuo* to a temperature sufficient to cause the Si and Al to alloy with Fe particles, but insufficient to cause substantial sintering together of the Fe particles.

(1298) Brit. 466,048 (1937). H. Vogt, *Process for Making Magnetic Powder.* It consists of producing an alloy in non-powdered form containing 82% Fe and more than 4% Si or Al, and disintegrating the alloy to a powder having no particles larger than 50 μ with a great percentage of them below 10 μ.

(1299) Brit. 484,908 (1938). Deutsche Edelstahlwerke A. G., *Material for Permanent Magnets.* The cast Fe-base alloy material is heated and rapidly quenched by immersion in a freezing mixture before comminuting into granular permanent magnet alloy powder.

(1300) Brit. 509,834 (1939). Glacier Metal Co., M. Melhuish and J. Bate, *Material for Bearings.* Production of material for bearings consists of melting a mixture of Fe (or Cu) with a lower melting material such as Pb, pouring the mass into an ingot, cooling, and pulverizing the ingot to powder, which is suitable for pressing and sintering.

(1301) U. S. 2,175,850 (1939). R. L. Patterson and C. G. Goetzel (Hardy Metallurgical Co.), *Powder Metallurgy.* Steel powder is produced by subjecting Fe powder alternately to carburizing and decarburizing atmosphere.

(1302) Belgian 448,517 (1942). Robert Bosch, G.m.b.H., *Preparation of Sintered Alnico Magnetic Alloys.* Scrap Alnico is molten and the jet directed against a rotating disc; the centrifuged particles are cooled in water, and yield a fine magnetic alloy powder suitable for the production of sintered or molded magnets.

(1303) U. S. 2,289,570 (1942). A. L. Boegehold (General Motors Corp.), *Method of Making Powdered Material and the Usage Thereof.* An alloy powder of low coercive force is produced by atomizing a molten composition of Ni and Fe and 1-4% C, and cooling rapidly and comminuting and decarburizing the particles to

form an alloy powder composed of Ni and Fe, and containing not more than 0.05% C.

(1304) U. S. 2,351,462 (1944). G. Trageser (General Aniline & Film Works), *Pulverulent Metallic Substance for Electromagnetic Purposes.* Process of producing Ni-Fe alloy powders for electromagnetic purposes comprises the thermal decomposition of a mixture of $Ni(CO)_4$ and $Fe(CO)_5$, coating the metal particles with inorganic halides which are not volatile at high temperatures, heating the coated powder in non-oxidizing atmosphere, and removing the greater part of the solid halides from the heated particles.

(1305) U. S. 2,354,727 (1944). J. Wulff, *Stainless Steel Powder.* Powder is produced by crushing contaminated residue containing stainless steel, and by work-hardening the metal, subjecting it to magnetic separation and to the action of a solution to passivate the steel.

(1306) U. S. 2,356,807 (1944). J. Wulff, *Alloy Powder.* Production of clean annealed alloy steel powder from superficially contaminated alloy steel particles comprises heating them in a fused bath at a temperature which will effect the formation of an embrittled or corrodible intergranular phase in the steel, and removing the contaminants; after withdrawal of the material from the bath, the intergranular phase is separated from the alloy grains.

(1307) U. S. 2,359,401 (1944). J. Wulff, *Metal Powders.* In stainless steel powder of the 18-8 Cr-Ni type for metal spraying a lower melting metal is incorporated to improve the adherence of the steel to the base material on which it is sprayed.

(1308) U. S. 2,362,512 (1944). M. J. Udy, *Metallurgy.* Ferrochromium alloys low in C are produced in powder form from finely divided ore.

(1309) U. S. 2,368,282 (1945). J. Wulff, *Steel Powder.* It is produced from stainless steel grinding residues which are heat treated, and quenched in a pickle-liquor to remove abrasive material; the-100 mesh to -200 mesh fraction is then separated and the oversize material ground.

(1310) U. S. 2,370,396 (1945). J. J. Cordiano (Hardy Metallurgical Co.), *Powder Metallurgy.* A steel powder is produced whereby a majority of the particles are fritted into agglomerates by heat treatment of a loose powder mass of finer soft Fe particles with finer ferrous alloy particles containing combined C.

(1311) U. S. 2,372,696 (1945). N. K. G. Tholand, *Powder Metallurgy of High-Speed Steel.* High-speed steel powder is produced by mechanically disintegrating a ferrous metal alloy with substantially larger amount of C than that desired in steel powder, and then decarburizing.

(1312) U. S. 2,381,022; 2,381,023; 2,381,024 (1945). J. Wulff, *Iron Alloy Powders, Apparatus and Process for Producing Them From Cheap Source Material.* Method of production of Fe and Fe alloy powders comprises disintegration of white cast Fe, gray cast Fe or reject metal shot, to form components rich and poor in C, and separating and recovering the components. The reject fines are subjected to a pickling operation, washing, carburizing, and magnetic separation to recover the magnetic constituents. The apparatus consists of a furnace with attached quenching means, a device to disintegrate the shotted material, and a magnetic separator.

(1313) Brit. 575,343 (1946). J. J. Cordiano (Hardy Metallurgical Co.), *Metal Powder for Manufacturing of Steel.* Method of production comprises fritting at 700-800° C. (1290-1470° F.) of fine Fe powder with fine ferrous alloy particles containing fixed proportions of C, and subjecting the mixture to mild comminution.

(1314) Brit. 578,193 (1946). General Electric Co. Ltd., *Manufacture of Nickel-Iron Alloy.* Ni-Fe alloy powders are produced from the sulfates of the elements.

(1315) French 919,479 (1946). E. H. Johansson, *Spherical Metal or Alloy Powder.* Spherical Fe alloy powder is made by reducing gaseous $FeCl_3$ with K-vapor in H_2-atmosphere at 20 mm. Hg, and by using electrodes of the alloy.

(1316) U. S. 2,394,578 (1946). J. Wulff, *Reclamation of Tool Steel Scrap.* Tool steel powder is produced from contaminated tool steel grinding scrap by sensitizing and chemical disintegration of the grain boundaries.

(1317) U. S. 2,407,862 (1946). J. Wulff, *Producing Metal Powders of High Alloy Content.* The production comprises a heat treating of a Cr-containing ferrous alloy with low Si-content in solid phase at a temperature which effects an intergranular carbide precipitation, then disintegrating the material, and separating the granular from the intergranular material.

(1318) Brit. Appl. 34526/47 (1947). D. Primavesi, *Production of Pseudo-Alloys.* Fe-Cu powder is produced either by roasting a chalcopyrite or by reduction of mixed chlorides with H.

(1319) French 920,210 (1947). E. H. Johansson, *Ferrous Powder by Electrolytic Reduction of Oxides.* Mill scale or Fe ore is electrolytically reduced in a fused NaOH bath, containing halides or carbonates. Oxide materials are introduced as porous sintered tubes or as powder; powders produced include Mn-, W-, Cr- and stainless steels.

(1320) U. S. 2,429,648 (1947). I. Rennerfelt and B.M.S. Kalling, *Alloys Low in Carbon.* Method of producing ferrochrome low in C from chrome or consists in preparing an alloy in finely divided state, including Fe and Cr, by reducing the ore and adding Fe to bring the Cr content to 20-30%.

(1321) French 933,849 (1948). Indiana Steel Products Co., *Amalgam for Use as Permanent Magnets.* It is made by depositing Fe electrolytically at a Hg cathode which contains up to 5% each of Cu or Zn, and regulating the final Hg content to 30-55% by exuding and evaporating.

(1322) Indian 34,764 (1948). Tata Iron & Steel Co. Ltd., *Ferrotitanium.* The crushed ore is mixed with CaO, Na_2CO_3 and C, and the mixture is briquetted and sintered at 1100° C. (2010° F.) in a reducing atmosphere.

(1323) U. S. 2,454,020 (1948). L. F. Weitzenkorn and G. N. Goller (Armco Steel Corp.), *Ferrochrome Process.* Method comprises heating ferrochromium low in C with 70% Cr in form of crushed lumps to 925-1315° C. (1700-2400° F.) in contact with N-containing material, maintaining the temperature for 6 hours, to effect nitrogenation of the Fe-Cr alloy, to have an N content of 0.7%.

(1324) Brit. 612,105 (1949). N. K. G. Tholand, *Production of High Speed Steel Powder.* Molten high speed steel with 1.5-3% C is granulated, embrittled by heat treatment, pulverized, and decarburized to 0.5-0.8% C. The powder can then be further processed, *e.g.*, hot-pressed or hot-forged.

(1325) French 950,003 (1949). M. Ungeheuer, *Production of Steel Powder.* Process involves reduction of crushed and graded mill scale with H_2.

(1326) U. S. 2,468,103 (1949). G. W. Pawel, *Production of Ferronickel.* Raw ground high magnesia garnierites are classified into a fine and a coarse fraction. The coarse fraction is digested with HCl; the acid slurry is filtered and the washed insolubles are rejected. The filtrate is neutralized with MgO and the resulting Fe–Ni–hydroxide precipitate is filtered and combined with the fines and smelted.

(1327) U. S. 2,473,091 (1949). H. Erasmus (Union Carbide & Carbon Corp.), *Production of Ferrochromium.* The C and S contents of high-C, high-S ferrochromium are reduced by heating pellets in mixtures with silica and chromic acid under vacuum at 1200-1300° C. (2190-2370° F.).

(1328) U. S. 2,488,926 (1949). J. M. Mousson (Armco Steel Corp.), *Process of Desulfurizing Stainless Steel Grinding Dust.* Stainless steel grinding dust is heated to 1480-1595° C. (2700-2900° F.) in air, thus forming a de-sulphurized sinter. The sinter is crushed and this material, in admixture with carbonaceous fuel, is subjected to re-sintering to form a product with an S content not exceeding 0.02%.

iii. Non-Ferrous High-Melting Alloys (Brass, Bronze, Nickel-Base Alloys, Precious Metal Alloys)

(1329) German 88,415 (1896). Allgemeine Elektrizitäts-Gesellschaft, *Bronze Powder.* Bronze powder is produced by electrolytically depositing loosely coherent metallic crystals and then grinding them into powdered form.

(1330) U. S. 762,932 (1903). K. Huth, Bronzefarbenwerke A. G., *Process of Manufacturing Bronze Powder.* Manufacture of bronze powder consists in bringing liquid metal into contact with rotary means to form bands therefrom and stamping bands to fine powder.

(1331) U. S. 946,738 (1910). A. Sang, *Method of Manufacturing Brass Dust.* Method comprises mixing Cu-dust plus Zn-dust and heating to a moderate temperature.

(1332) U. S. 1,347,927; 1,347,928 (1920). M. Baer, *Bronze Powder.* Method comprises cooling fluid metal in the presence of H_2O for rendering it porous and subjecting it to hammering in the presence of a liquid such as oil or fat.

(1333) U. S. 1,680,825 (1928). W. R. Veazey (Dow Chemical Co.), *Method of Pulverizing and Alloying Nickel.* Heating together metallic Ni and Mg at a temperature below the melting point of former, but above that of latter, until sufficient Mg is absorbed by Ni to render it pulverizable.

(1334) Brit. 312,441 (1929). General Electric Co. Ltd. and R. W. W. Sanderson, *Manufacture of Nickel-Iron Alloys.* A Ni-Fe alloy is produced in a friable condition by electro-deposition at a high current density from a solution containing compounds of the two metals. The alloy deposit can be pulverized; and the powder is suitable for pressing into magnet shapes.

(1335) German 533,179 (1931). E. Oeser, *Bronze Powder.* Bronze powder is produced electrolytically on an endless belt with small depressions and a non-conductive coating.

(1336) U. S. 1,792,262 (1931). W. C. Wilson, *Finely Divided Metals Such as Combined Zinc and Copper.* Method for preparation of finely divided metals and alloys comprises reducing the metals from one of their salts by intimate contact in dispersed state with a precipitant metal.

(1337) Brit. 413,526 (1934). Heraeus Vacuumschmelze A. G. & Standard Telephone & Cables Ltd., *Magnetic Alloy Powders.* They are produced by reduction of crystals, crystallized from solution of isomorphous salts composed of 80% Ni and 20% Fe, and are suitable for magnetic cores.

(1338) U. S. 2,199,191 (1940). G. Tour (United States Metal Powders Inc.), *Bronze Powders.* In a process of making metal flakes, flitters or shrode of metals such as Al, bronze or Au bronze, drops of molten or plastic metal are rolled through chilled rolls.

(1339) Brit. 565,055 (1944). Chrysler Corp., *Powdered Metal Mixtures.* Powdered Cu-Sn mixture is produced by fusing together predetermined proportions of Cu and Sn to form an alloy having a high degree of brittleness, and fracturing readily, and reducing the solidified alloy to powdered form under impact.

(1340) U. S. 2,373,158 (1945). J. Wulff, *Brass Powders.* A powdered brass comprises particles of a core of brass of a relatively high Zn content and an integral case of a lower Zn content, and is produced by utilizing a raw material containing over 36% Zn, forming β-brass which is easily shotted or atomized, and then annealing to volatilize the excess Zn. Sintering is controlled to assure diffusion of the Zn from core to case.

(1341) Brit. 574,583 (1946). Telephone Manufacturing Co. Ltd. and L. H. Paddle, *Production of Nickel Alloys by Powder Metallurgy Methods.* Powders of the individual constituents are intimately mixed in the required proportions, compressed and heated and quenched, then mechanically reduced to powder. Process is suitable for production of Ni–Mo–Fe magnetic alloy powder.

iv. Nonferrous Low-Melting Alloys (Light Metal Alloys, Bearing Metal Alloys, Amalgams)

(1342) U. S. 114,848 (1871). J. G. Phillips, *Amalgamating Process.* To prevent loss of Hg during amalgamation with Au, Zn chips and strips of Cu are added.

(1343) U. S. 336,824 (1886). D. J. Riker and S. Crump, *Matrix.* It consists of a powdered compound formed of a primary metal such as Pb plus Hg, which is suitable for compression.

(1344) U. S. 547,824 (1895). C. N. Vigneron, *Amalgamating Compound.* To make Hg more effective in amalgamation with precious metals, powdered Al is acted on by Cu_2SO_4 and introduced into the Hg.

(1345) German 144,134 (1903). Bronzefarbenwerke A. G., *Production of Aluminum-Bronze Powder.* The fluid metal is poured out into a groove, through which water is running, to carry the metal into a water basin.

(1346) U. S. 794,552 (1905). G. M. Rice, *Art of Treating Ore.* Finely divided Cu or Ag is added to Hg - containing Au amalgam to unite the Au as an alloy.

(1347) U. S. 1,859,036 (1932). E. J. Hall (Metals Disintegrating Co.), *Method and Material for Clearing Drain Pipes and for Other Uses.* Al powder is alloyed with Si, and the particles are graded into predetermined sizes.

(1348) U. S. 1,871,450 (1932). J. A. Gann (Dow Chemical Co.), *Production of Metal Powders.* Method comprises passing brittle Mg-Al alloy and polished flake Al through a pulverizing zone.

(1349) Brit. 438,552 (1935). General Electric Co. Ltd., *Production of Metal Powders.* Method comprises subjecting a Pb alloy to a powdering process, when it is at a temperature within its melting range; during the cooling to the lower end of the melting range, the powdering process is continued, so that the particles do not weld together.

(1350) French 826,618 (1938). Metallgesellschaft A. G., *Zinc Dust Containing Cadmium.* Method of production comprises fusing mixed powders in rotating drum, volatilizing, precipitating and reducing.

(1351) U. S. 2,123,300 (1938). K. R. Göhre (American Lurgi Corp.), *Process for Working Up Zinc Dust.* Process for working up Zn dust which contains Cd comprises liquating the dust in the absence of a reducing agent, and subjecting the resulting Cd-Zn alloy to rectification.

(1352) U. S. 2,251,089 (1941). H. von Zeppelin, *Process for the Production of Alloys Containing Beryllium.* Reacting a powdered halide compound with a reducing metal by heating the mixture to a temperature sufficient to cause formation of the alloy.

(1353) U. S. 2,353,612 (1944). D. Gardner (Virginia Metal Industries Inc.), *Alloys Such As Those of Be and Mn.* Metals having substantially the same boiling points such as Mn and Be are preliminarily mixed with each other in crushed form and are jointly vaporized and condensed to obtain a non-brittle product of high purity.

(1354) Japan 172,653 (1946). K. Ono, *Refining of Impure Aluminum-Silicon Alloy.* Al-Si is granulated and 2% Mn are added; the mixture is treated with steam and centrifuged to remove Fe and other impurities.

(1355) Brit. 592,506 (1947). Murex Ltd. and G. L. Miller, *Aluminum Alloy.* A powdered 40-60 Co-Al alloy for sintered Alnico magnets is made by igniting a 31:44 mixture of the oxides.

(1356) Brit. 602,111 (1948). R. Morane and R. Martinet, *Manufacture of Metal Grains.* The flow of a molten Pb-As alloy from the pot to the distributing ladle is automatically regulated by the amount of the alloy in the ladle; from there the metal flows down through oscillating chutes on to rotating screens to produce the Pb alloy powder.

(1357) Japan 174,876 (1948). Y. Konishi and T. Okamoto, *Separation of Iron from Aluminum Scrap.* Al-Fe alloy scrap is molten at temperature higher than the eutectic temperature and passed through compressed air to separate crystals of Fe content and slag, and to granulate the Al alloy.

C. Compound Powders

i. Carbides

α. Metal (Tungsten, Molybdenum, Titanium, Tantalum, Columbium, Vanadium, Zirconium)

(1358) Brit. 316,103 (1929). Bayrische Metallwerke A. G., *Powdered Metals Containing Hydrocarbon.* Metals, alloys or metal oxides of W, Cr, V, or Ti are heated in the powdered state in a hydrocarbon atmosphere. Reaction may be carried out at higher than atmospheric pressure for binding the hydrocarbons with the metal.

(1359) Brit. 319,698 (1929). British Thomson-Houston Co. and F. C. Kelley, *Making Tungsten Carbides.* Method consists of placing W and C powder in a porous carbonaceous receptacle in hydrogen and heating the mixture to cause combination of the metal and C, the rate of diffusion through the receptacle being such that no H_2 entering the receptacle remains uncombined with the C.

(1360) U. S. S. R. 32,158 (1931). B. I. Belyaev and I. S. Gaev, *Reduction of Tungsten Oxide.* WO_3 is reduced with 14% C at 1350° C. (2460° F.); the resulting W is ground and mixed with C, to produce WC and W_2C in an electrical furnace.

(1361) Austrian 132,692 (1933). A. Kratky, *Production of Hard Carbides.* Powdered anthracite or bituminous coal is air-sealed and annealed in atmosphere of H_2, N_2, or CO_2 to produce very small and porous particles, which are then used for mixing with metal powders, and subjected to carburization treatment.

(1362) Brit. 406,822 (1934). Firth Sterling Steel Co., *Hard Cemented Carbide Material.* Ti is added to a mixture of TiC and Co as a decarbonizing metal, so that it will form more TiC by combination with free C.

(1363) French 765,893 (1934). S. A. Union Aciers Fin, *Material for Hard Carbide Tools.* The carbides are produced directly in gaseous state and condensed to very fine powder. $TiCl_4$ or $MoCl_6$ are introduced in gaseous form into the reaction chamber, filled with hydrocarbon gas, and heated at 2000° C. (3630° F.), forming TiC or Mo_2C by precipitation. A hydrocarbon-hydrogen gas mixture is passed over a solution of tungsten carbonyl in benzol, and then through a C tube at 1200-1400° C. (2190-2550° F.) in which WC is deposited.

(1364) Austrian 141,832 (1935). Vereinigte Edelstahl A. G., *Multistage Method for Production of Titanium Carbide.* It comprises first an incomplete carburization at 1500-1700° C. (2730°-3090° F.), then addition of the missing C, and then final carburization at 1500-2000° C. (2730-3630° F.), to produce high quality TiC for hard metal.

(1365) Brit. 435,754 (1935). Vereinigte Edelstahl A. G., *Production of Carbides.* Production of carbides from carbonitrides (*e.g.* tungsten carbonitride), borides, or silicides, by heating the compounds in the gaseous state within the free space of a chamber up to 2500° C. (4530° F.) to dissociate the compounds, and subsequently combining the elements formed to compounds (*e.g.* WC) which are precipitated from the chamber.

(1366) Swiss 184,622 (1935). C. Trenzen, *Production of Tungsten Carbide.* W is separated on a metal plate from tungsten carbonyl at 300° C. (570° F.) and the mass is heated for carburizing in a CO-benzol gas mixture at 970° C. (1780° F.).

(1367) Austrian 149,652 (1937). Vereinigte Edelstahl A. G., *Production of Carbides, Nitrides, Borides, Silicides for Hard Metal Alloys.* The compounds are produced from the gases by precipitation to produce amorphous powders, and using carbonyls as starting material. Method is especially suitable for production of WC.

(1368) Brit. 471,792 (1937). N. Sainderichin (Follsain Syndicate Ltd.), *Metal Carbides by Heating Powdered Metal with Carbonizing Mixture.* Process for producing metal carbides consists in heating the metals, *e.g.* W or Mo, in finely divided condition and mixing them with a carburizing material containing MnO_2 in a hermetically sealed box.

(1369) French 811,511 (1937). P. Marth, *Production of Hard Material.* Powdered carbides (or borides) of W, Mo, Ti, V, Zr, Ce, Si, Be, Al are produced by heating in an electric arc to 3400-3600° C. (6150-6500° F.).

(1370) Brit. 478,016 (1938). P. Marth, *Production of Hard Material Powders. Cf:* French 811,511 (No. 1369).

(1371) Brit. 485,021 (1938). Societé Générale Métallurgique de Hoboken, *Tantalum and Columbium Carbides Production.* Carbides of Ta and/or Cb are produced from the ores by subjecting them to a reducing operation in the presence of Fe and an excess of C, and subjecting the impure alloy to chemical treatment to separate the carbides of Ta and Cb therefrom.

(1372) French 828,551 (1938). Vereinigte Edelstahl A. G., *Hard Carbides Powder Production.* Fe-Ta or Fe-Cb concentrates are reduced to powder, mixed with C, heated to 1900-2200° C. (3450-4000° F.), and treated with HCl and HF.

(1373) Swiss 193,402 (1938). P. Marth, *Production of Hard Material.* WC is fused and electrically heated by an electric arc between electrodes of Mo to 3450° C. (6270° F.) in the presence of H_2, which is split into its atoms, forming a gaseous layer above the melt; the cooled product is crushed and pulverized, the powder being suitable for boring tools.

(1374) Swiss 198,771 (1938). Rheinmetall Borsig A. G., *Production of Hard Metal Bodies Consisting of Two Hard Metal Powders.* 6-8 parts of W or Cr are mixed with 3-5 parts of titanic acid, vanadic acid and C, to produce in the mixture a chemical reaction, to form the hard metals in powdered form.

(1375) U. S. 2,134,305 (1938). R. Kieffer (American Cutting Alloys Inc.), *Method of Manufacturing Hard Metal Alloys.* Preparation of complex carbides from W, Mo, Ta, Ti, Zr, Cr, and additions of Si and B, comprises reducing oxides obtained from the ore.

(1376) U. S. 2,137,144 (1938). N. Sainderichin (Follsain Syndicate Ltd.), *Metal Carbides.* Method of production consists of heating Fe, W and Mo in finely divided condition in a carburizing mixture of charcoal, MnO_2, caustic potash and NH_4Cl.

(1377) U. S. 2,138,672 (1938). F. F. White (General Electric Co.), *Pulverizing Hard Cemented Carbide Compositions Such As in Salvaging Operations.* Method consists of heating cemented carbides in a carbonaceous atmosphere and at temperatures sufficiently high to cause them to assume a spongy condition, and then cooling and pulverizing.

(1378) Brit. 509,609 (1939). Vereinigte Edelstahl A. G., *Production of Hard Metal.* Ferrotantalum or ferrocolumbium or both are mixed with graphite and sintered at 1400-2200° C. (2550-3990° F.), then comminuted and treated with acids.

(1379) German 680,566 (1939). I. G. Farbenindustrie A. G. and O. Meyer, *Production of Titanium Carbide Free from Graphite.* TiC powder containing free C is mixed with a small quantity of Mn powder and heated to 900° C. (1650° F.) to form Mn_3C which is leached out with diluted acid.

(1380) Swedish 96,248 (1939). Deutsche Edelstahlwerke A. G. and R. Kieffer, *Production of Tantalum and Columbium Carbides.* Method of production of TaC and CbC, especially for the production of hard metals, comprises mixing powdered ferrotantalum or ferrocolumbium, or a powdered mixture of these two ferroalloys, with a material giving off C, after which the mixture is heated at a temperature from 1400 to 2200° C. (2550 to 4000° F.), preferably in a graphite crucible. The carburized product, after mechanical comminution and separation, is treated with acids.

(1381) U. S. 2,155,682 (1939). R. R. Ridgway (Norton Co.), *Abrasive Metal Carbides Manufacture.* A mixture of C and metal oxide is charged into a sealed electric furnace, followed by heating the central zone of the charge to synthesizing temperature and forming metal carbide in non-oxidizing atmosphere.

(1382) U. S. S. R. 56,245 (1939). G. A. Meerson, *Powder Production for Hard Alloy with a Complex Carbide Component.* Powdered oxides or salts of Ti or Zr and of W or Mo are heated with C. Acceleration of the reduction and carburization is achieved by adding at least two oxides or salts of Cu, Ag, Co, Ni which are not to exceed 5% by volume.

(1383) Austrian 157,947 (1940). Deutsche Edelstahlwerke A. G., *Production of Mix-Crystals of Carbides of Tantalum and Columbium.* Powders of ferrotantalum and ferrocolumbium and C are heated to 1400-2000° C. (2550-3630° F.); the product is crushed and treated with a mixture of HCl and HF.

(1384) French 863,628 (1941). J. Barbou, *Metal Carbides.* Scrap strips of W, Mo, or Ta are heated in oxidizing atmosphere at 1600° C. (2910° F.), cooled and powdered, then heated again at 1600° C. (2910° F.) with C to make the carbide.

(1385) German 702,629 (1941). Pintsch Komm. Ges. and H. J. Schneider, *Production of Homogeneous Metal Carbides.* The metal and the free C are co-precipitated in their stoichometric proportion corresponding to the composition of the carbide on backing by cathodic atomization; the deposited mixture is then heated alone or with the backing.

(1386) Italian 388,737 (1941). Westinghouse Electric & Manufacturing Co., *Process for the Production of Metal Carbides.* Invention consists chiefly of the production of a carbide of W containing a roughly theoretical combined C content corresponding to the chemical formula WC, and containing practically no free C.

(1387) U. S. 2,237,503 (1941). R. R. Ridgway (Norton Co.), *Titanium Carbide and Method of Making Same.* TiC is made from precipitated TiO_2 in form of purified powder, by shrinking it to a dense form by electric fusion and crystallizing it to a material of high density; then the mass is crushed and mixed with C to produce the carbide in an electric furnace.

(1388) French 872,041 (1942). Soc. Industrielle et Commerciale des Aciers, *Hard Metal Alloys.* 100 parts of WO_3 are mixed with 25 parts TiO_2, 7 parts CoO and 33 parts soot, and heated in reducing atmosphere, then cooled and crushed.

(1389) French 872,853 (1942). Soc. Industrielle et Commerciale des Aciers, *Production of Hard Alloys.* WC and TiC powders are obtained by heating WC and TiN with addition of C.

(1390) Brit. 560,458 (1944). Barrow Haematite Steel Co. Ltd., W. B. Hamilton and W. Killingbeck, *Hard Carbides.* W_2C is produced by heating WO_2 with C with the aid of a conductive primer by eddy currents generated at radio frequencies between 250,000 and 750,000 cycles per second.

(1391) Czech. 73,562 (1944). (Bohem. & Morav. Protectorate). Anonymous, *Hard Metal Body of Different Metals.* The metals are carburized in stages and crushed intermediately.

(1392) German 745,269 (1944). Deutsche Edelstahlwerke A. G. and C. Ballhausen, *Procedure and Apparatus for the Production of Metals and Their Carbides.* Ti, W, Mo, Ta, Cb, Fe, Zn, Al, Ca or other metals taken in the form of their oxides or oxidic ores are intimately mixed with powdered lamp black, coke, graphite or similar material. Mixture is pressed and heated in electric current in which it acts as resistor. The metal-carbon mixture is compressed to a degree at which the gases generated in the reaction can escape freely.

(1393) U. S. S. R. 64,928 (1944). A. N. Zelikman, V. S. Rakovski, and R. L. Bogdanovskaya, *Recovery of Sintered Carbide Scrap.* WC-Co scrap is heated to 1200-1400° C. (2190-2550° F.), water quenched and reground.

(1394) Brit. 567,780 (1945). Barrow Haematite Steel Co. Ltd., *Hard Carbides.* A mixture of C and an element producing a hard carbide, such as W, Ti, Mo, B, is heated by generating eddy currents in the mixture by radio-frequency of electromagnetic wave energy.

(1395) Brit. 577,072 (1946). E. A. Pokorny, *Hard Carbides.* Hard carbides of W, Mo, Ta, Cr are manufactured by carburizing the metals in form of their alloys with Fe, Ni, Co, and filtering the suspension of the carbide in the liquid alloy through a refractory filter.

(1396) Brit. 582,921 (1946). E. M. Trent (Powderloys Ltd.), *Process of Separating Hard Constituents from Sintered Hard Metals.* Coarsely crushed scrap material comprising hard metal carbides and an auxiliary metal of the Fe group is fused with Zn to form an alloy, which later is removed by a solvent, *e.g.* dilute H_2SO_4, followed by washing to separate the hard carbide particles.

(1397) U. S. 2,407,752 (1946). E. M. Trent (Powderloys Ltd.), *Process of Separating Hard Constituents from Sintered Hard Metals. Cf.:* Brit. 582,921 (No. 1396).

(1398) French 921,850 (1947). Soc. Pour L'Elaboration Scientifique Du Tungsten. *Recovery of Hard Metal Carbides.* Scrap carbides are treated at 800° C. (1470° F.) with O_2 under high pressure. CO_2, which is evolved, is absorbed by lime or barytes.

(1399) Brit. 606,117 (1948). G. J. Trapp, *Recovering of Hard Metal Carbides.* Carbide scrap is heated to 1800° C. (3270° F.) in a reducing atmosphere until it cracks, whereby some Co is exuded; after cooling the material is boiled in HCl solution, washed and ball-milled. The end product is a high quality WC.

(1400) Brit. Appl. 6927/48 (1948). British Thomson-Houston Co. Ltd., *Material for Porous Cemented Carbides.* Spherical granules are made by spilling a molten mixture of carbide and binder onto a vibrating trough set at an angle of 15 to 45°; the size of the granules is determined by the angle of the trough, the intensity of vibration, and the amount of powder spilt.

(1401) Brit. Appl. 18912/48 (1948). Vanadium Corp. of America, *Preparation of Pure Metallic Carbides.* Crude carbide containing free graphite is reduced by roll crushing, followed by ball-milling, to give the minimum amount of fines. Then material is subjected to froth flotation. For example, TiC with 1.29% graphite is crushed to −20 mesh, and then ball-milled dry to 96% −325 mesh. The filter cake from the flotation machine contains 0.31% graphite, with 97% TiC recovery.

(1402) U. S. 2,448,479 (1948). H. A. Wilhelm and A. H. Daane (U. S. A. − Atomic Energy Commission), *Uranium Monocarbide.* The carbide is obtained by heating a mixture of UO_3 and C, pressing and heating to 2300° C. (4170° F.) for 20 minutes; the product has the composition $U_1C_{1.27}$.

(1403) Brit. 618,527 (1949). S. A. Le Carbone-Lorraine, *Process of Refining Refractory Carbides. Cf.:* French 949,922 (No. 1405).

(1404) Brit. 623,577 (1949). E. A. Pokorny and H. W. Pokorny, *Recovery of Hard Metal Carbides.* Scrap is heated to 1500-1650° C. (2730-3000° F.) in an atmosphere containing S or cracked NH_3 to saturate the binding metal with C, followed by cooling slowly and dissolving the Co, Ni or Fe alloy with HCl or H_2SO_4.

(1405) French 949,922 (1949). S. A. Le Carbone-Lorraine, *Refining Refractory Carbides.* O and N are removed from TiC with simultaneous formation of a double carbide Ti_3WC_4, by heating a mixture of 100 parts TiC, 108 parts WC and 1.5 parts lampblack under vacuum at 2000° C. (3630° F.).

(1406) U. S. 2,485,175 (1949). G. J. Trapp, *Method of Recovering Hard Metal Carbides From Sintered Masses.* A process is disclosed wherein a cemented carbide mass is heated in a non-oxidizing atmosphere to cause swelling and cracking; the porous mass is then cooled and treated with acid to remove the metallic Co; and the resultant hard metal carbide is then subjected to mechanical reduction.

(1407) U. S. 2,491,410 (1949). C. C. Laughlin and E. Wainer (National Lead Co.), *Graphite-Free Titanium Carbide.* TiC is made from rutile and petroleum coke mixed with 1% Cr_2O_3, to form a volatile chromium carbide with the free graphite, and, after firing at 2200° C. (3990° F.), leaving a Cr content in the TiC equivalent to 1.5-3% Cr_2O_3.

β. Nonmetal (Boron, Silicon)

(1408) German 327,509 (1920). E. Podszus, *Method of Producing Boron Carbides.* It employs BNO_3 which is reduced by C in the electrical arc.

(1409) German 408,354 (1925). Elektrochemische Werke A. G., *Method of Producing Boron Carbides.* Method of producing carbides of boron comprises melting compounds of boron together with charcoal or coke and Al in an electrical furnace.

(1410) French 780,367 (1935). Norton Co., *Boron Carbide.* B_4C is produced in crystalline state, suitable for solid articles.

(1411) Brit. 486,817 (1938). Norton Grinding Wheel Co., Ltd., *Boron Carbide Production.* Method comprises electrical heating under synthesizing conditions a furnace charge of B_2O_3 and a C-forming product.

(1412) French 822,754 (1938). Comp. Des Meules Norton, *Production of Boron Carbide.* The production of B_4C takes place in an electric furnace by heating a mixture of B_2O_3 and C.

(1413) German 669,558 (1938). Norton Co., *Boron Carbide Powder.* Boron carbide without free C and having a B content higher than in B_4C is produced by the reaction of C with B_2O_3 in an electric furnace by laying around the resistor a mixture of the trioxide and C.

(1414) U. S. 2,141,617 (1938). R. Ridgway (Norton Co.), *Boron Carbide Alloys.* Method for producing B_4C alloy comprises electrically heating B_2O_3 and C.

(1415) German 672,552 (1939). Norton Co., *Boron Carbide Powder.* Production of B_4C without free graphite is disclosed from the anhydride of boric acid and C in an electric furnace.

(1416) German 673,534 (1939). I. G. Farbenindustrie A. G., *Boron Carbide Powder.* B_4C is produced from H_3BO_3 and C in an electric furnace.

(1417) German 677,189 (1939). Dr. Alexander Wacker Ges. für Elektrochemische Ind., *Boron Carbide Powder.* H_3BO_3 and C are fused together, crushed, mixed again with boric acid and fused.

(1418) Brit. Appl. 13255/48 (1948). F. Swarovski, *Manufacture of Boron Carbide.* A high grade B_4C, with a composition having no free C, is made with a certain, small Fe content, either inherent in the coke used or added separately, and a certain P content, which is 0.5-20% of the Fe content.

ii. Nitrides (Tungsten, Molybdenum, Titanium, Tantalum, Columbium, Vanadium, Zirconium, etc.)

(1419) U. S. 1,803,276 (1931). R. Walter, *Homogeneous Metalliform Carbonitrides.* Production of tungsten carbonitrides comprises the carburization and nitrification reactions with W to occur in the presence of C and N during heating.

(1420) U. S. 2,461,018; 2,461,019; 2,461,020 (1949). P. P. Alexander (Metal Hydrides, Inc.), *Production of Titanium Nitride, Zirconium Nitride, and Tantalum Nitride.* The charge consisting of the metallic powder is heated, then subjected to N and NH_3 to convert the Ti to powdered TiN. The TiO_2 for the production of the Ti may be TiO_2 pigment in finely divided form and the reducing metal may be Ba, which is leached out with a solution of acetic acid.

(1421) U. S. 2,467,647 (1949). P. P. Alexander (Metal Hydrides, Inc.), *Process for the Production of Metal Nitrides.* Alkaline earth metals may be nitrided according to this process. The method consists in heating a charge of the metal in finely divided form, in the absence of air and in the presence of a limited amount of N_2, in a reaction zone to a temperature sufficiently high to cause the N_2 to begin to combine with the metal to form the desired metal nitride, but insufficiently high to cause the metal to fuse.

(1422) U. S. 2,487,474 (1949). J. L. Porter (The Permanente Metals Corp.), *Preparation of Magnesium Nitride.* Mg vapor is conducted in the presence of an inert carrier gas, but in the absence of an O yielding gas, into a reaction zone where it is admixed with N_2 or NH_3 at 300° C. (570° F.), whereupon pure Mg_3N_2 is produced and collected.

iii. Borides (Tungsten, Zirconium, etc.)

(1423) U. S. 2,088,838 (1937). N. W. Cole and W. H. Edmonds, *Hardening Material Resistant to Heat.* CrB_2 crystals are embedded in a matrix of CrB and other concomitant materials produced by aluminothermic reduction of intermixed Cr and B oxides.

iv. Silicides and Silicates

(1424) German 294,267 (1916). E. Wedekind (Julius Pintsch A. G.), *Production of Silicides of Tungsten or Molybdenum.* W or Mo are mixed with Si, heated to 1200° C. (2190° F.) for alloying the elements below the melting point of the Si.

v. Oxides (of Refractory Metals, Ferrous Metals, Light Metals)

(1425) German 141,811 (1902). E. F. J. Clotten, *Decomposition of Tungsten Ore with Bisulfate.* The ore is ignited with $NaHSO_4$, then blended with a mixture of bisulfate and lime or calcium chloride, with an addition of alkali chloride, followed by raising the temperature to 800° C. (1470° F.).

(1426) German 149,556 (1904). Elektrochemische Fabrik Kempen, *Production of Pure Tungstic Acid.* W ore is fused together with NaS_2 and sulfuric acid, the solution containing the W as sodium acid tungstate; the sodium sulfate is deposited and the tungstic acid is precipitated by addition of HCl.

(1427) German 221,062 (1907). G. A. Hempel, *Obtaining Tungstate.* A cleaner tungstate is obtained when a small percentage of caustic lime is added to the caustic alkali used to treat wolframite ore in an autoclave.

(1428) U. S. 946,970 (1910). C. M. Johnson, *Decomposition of Tungsten Ores.* HCl is added to wolframite or scheelite and some $NaClO_3$, heated to 90° C. (194° F.) for 10 to 18 hours; the residue washed out with water consists of tungstic acid and silica dross.

(1429) U. S. 1,049,193 (1912). T. Ban, *Decomposition of Tungsten Ores.* Finely powdered wolframite is heated with strong HCl and cooled, and the washed residue is treated with a bleaching powder solution and HCl, whereby the calcium hypochlorite will liberate chlorine in the nascent state, and dissolve Fe and Mn.

(1430) Brit. 17,603/1912 (1913). C. H. Fischer, *Treating of Tungsten Ore.* Potassium tungstate solution is treated with ammonium sulfide, the metallic impurities are separated as sulfides, and the W remains in solution as WS_3; the filtrate is treated with hydrochloric acid for precipitation of WS_3 which is roasted in air to WO_3.

(1431) German 266,973 (1913). P. Jannasch, *Treatment of Wolframite.* Method consists of mixing the pulverized ore with CCl_4, quartz, or silica and heating to redness.

(1432) Brit. 10,117/1915 (1915). J. C. Butterfield and A. Ashworth, *Treating Wolframite Ore.* Wolframite ore is treated with boiling dilute H_2SO_4 and the residue is again treated with H_2SO_4, to complete the removal of iron or manganese oxide.

(1433) U. S. 1,244,082 (1917). L. Rosenstein and E. H. Simonds, *Extracting Trioxide of Tungsten.* The scheelite ore is finely ground, mixed with water, and Na_2CO_3 and NaOH are added; the mixture is then boiled to form soluble sodium tungstate and insoluble $CaCO_3$, while NaOH aids the dissolution. By treating with a barium compound barium tungstate is formed, which is treated with HCl.

(1434) U. S. 1,261,383 (1918). E. M. Hamilton, *Extraction of Tungstic Acid.* The ore is finely ground and made into pulp with water, to which either sodium carbonate or bicarbonate is added; the pulp is then heated in an autoclave equipped with an agitator, whereby tungstic acid is precipitated by treating the sodium tungstate with HCl.

(1435) Brit. 122,051 (1919). J. B. Ekeley and W. B. Stoddard, *Process for Extracting Tungstic Acid.* The process of treating ores of W, Mo or V consists of fusing the ores in a bath containing an alkali compound and a halide.

(1436) Brit. 134,891 (1919). O. J. Stannard, *Treating Tungsten Ore.* The crushed ore is mixed with carbonaceous material and heated to 300° C. (570° F.) in a current of dry Cl, so that the W volatilizes with Fe and Mn; by treatment with acidified boiling water the tungstic acid is precipitated.

(1437) U. S. 1,292,559 (1919). C. Andersen and E. H. Westling, *Separating Tungsten Compounds from Solution.* By adding a salt of a trivalent metal and an alkali metal hydroxide to the solution, a tungstate of a trivalent metal is precipitated.

(1438) U. S. 1,293,403 (1919). D. J. Giles and J. E. Giles, *Decomposition of Tungsten Ore.* The ore is treated with NaOH in a closed vessel under heat, so that silica and phosphorus are attacked, and their removal made possible by diluting the solution to 0.8% NaOH and adding CaOH in excess. The precipitated $CaWO_4$ is treated with HCl.

(1439) U. S. 1,322,485 (1919). J. B. Ekeley and W. B. Stoddard, *Treatment of Tungsten Ore.* Sodium hypochlorite, and a magnesium salt are successively added to the solution, to combine with phosphorus and arsenic acid; the solution then contains pure sodium tungstate.

(1440) French 522,682 (1920). C. C. Buré, *Decomposition of Tungsten Ore with Fused Alkali.* Wolfram ore is treated with NaOH under fusion; sodium tungstate is then obtained by leaching the fused product with water.

(1441) German 330,987 (1920). J. C. Blanch, *Producing Tungstic Oxide.* The ore is roasted with NaCl and then with an admixture of a nitrate; the roasted product is treated with H_2SO_4 and agitated with steam, and the resulting WO_3 is washed.

(1442) U. S. 1,399,245 (1921). W. F. Bleecker, *Extraction of Tungstic Acid.* The process proposes the use of H_2SO_4 to decompose sodium tungstate to tungstic acid.

(1443) Brit. 176,428 (1922). W. H. Dyson and L. Aitchison, *Treating Tungsten Ore.* Crushed wolframite or scheelite is agitated in a furnace at 600° C. (1110° F.), and a mixture composed of equal volumes of Cl and HCl gas is led over the ore, to volatilize the Sn; the temperature of the furnace is then raised to 1000° C. (1830° F.).

(1444) Brit. 181,837 (1922). Durelco Ltd., R. E. Pearson and E. N. Craig, *Treatment of Tungstic Oxide.* Powdered WO_3 is mixed with dilute H_2SO_4 into a paste, which is introduced into a porous cathode pot, and immersed in the H_2SO_4 electrolyte; nascent H is produced for the reduction of the oxide.

(1445) Brit. 185,842 (1922). Durelco Ltd., R. E. Pearson and E. N. Craig, *Decomposition of Tungsten Ore.* Ground wolframite is mixed with H_2SO_4 to a paste and placed on a Pb anode plate; by passing a current through the cell Fe, Mg, Sn, calcium or sodium oxides pass into solution, leaving a residue of tungsten oxide.

(1446) Brit. 187,111 (1922). S. A. "Le Nickel", *Ingots from Nickel-Oxides.* Process for making Ni ingots from crude nickel oxide consists in effecting partial reduction of the oxide, and powdering a lixiviating product with HCl and HF.

(1447) Brit. 189,873 (1922). British Thomson-Houston Co. Ltd., *Producing Tungsten Compounds from Tungsten Ore.* Method consists in fusing the ore and fusing ingredients to cause a reaction whereby the tungsten component of the ore is converted into a soluble compound and then treating the fused mixture with a solvent to secure the soluble compound of tungsten.

(1448) Japan. 41,953 (1922). G. Shimadzu, *Litharge for Electrodes.* Pb powder having an apparent density of 1 to 4 is spread in an iron pan and a small amount of heated litharge is added and the mixture heated; when the reaction is completed new litharge and Pb powder are added until all powder is converted to litharge.

(1449) U. S. 1,410,584 (1922). S. J. Lubowsky, *Production of Tungsten Trioxide.* The ore is roasted with $CaCl_2$ or $KClO_3$; the pulverized roasted product is treated with H_2SO_4, HNO_3 or HCl, the solid residue is treated with a solution of ammonium carbonate, and the ammonia is distilled off.

(1450) U. S. 1,431,559 (1922). F. M. Becket, *Treatment of Tinny Wolframite Ore.* In the treatment of tinny wolframite ore with caustic soda a roasting operation is necessary; therefore, the fine ore is first subjected to an oxidizing roast.

(1451) U. S. 1,481,697 (1924). W. H. Dyson, *Treating Tungsten Ore. Cf:* Brit. 176,428 (No. 1443).

(1452) U. S. 1,483,567 (1924). K. Anjow, *Treating Wolframite Ore.* The ore is finely pulverized and treated with acid under pressure in an autoclave fitted with a stirrer at a moderate temperature, to avoid the forming of films of sulfates or chlorides on the surface of the ore particles.

(1453) French 591,586 (1925). Comp. Française pour L'Exploitation des Procédés Thomson-Houston. *Decomposition of Tungsten Bearing Ores.* Wolframite (60% WO_3) is mixed with $NaNO_3$ in a weight ratio of 2:1 and a small amount of water is added.

(1454) U. S. 1,535,019 (1925). F. M. Dorsey, *Metallurgical Process.* It consists of preparing pure WO_3 from a solution of Na_2WO_4 by treating it with a reagent to precipitate the WO_3.

(1455) U. S. 1,629,004 (1927). P. Schwarzkopf, *Production of Tungsten- or Molybdenum-Trioxide from their Ores.* Method comprises roasting the subsequently fused ores and condensing the oxide vapors evaporated from the ore in the molten state.

(1456) U. S. 1,652,646 (1927). W. B. Stoddard, *Decomposition of Tungsten Bearing Ore.* The ore mixed with charcoal is reduced to powder, and water and sodium silicate are added and mixed; then sodium nitrate is added, and the mixture placed into a shallow, open receptacle and ignited, whereupon the combustion will propagate itself through the mass; the resulting soluble tungstate is separated by leaching.

(1457) Brit. 291,919 (1928). F. W. Wilder, E. Morris, E. Schiff, and E. S. King, *Decomposition of Tungsten Ore with Ammonia.* A solution of NH_3 gas in water is used to treat, under elevated pressure, complex ores containing W; by concentrating the resulting solution the paratungstate crystallizes out.

(1458) Austrian 113,107 (1929). Metallwerk Plansee G.m.b.H., *Production of Molybdic Acid or Tungstic Acid.* The concentrated roasted ore is heated so high that the respective acids evaporate and then can be condensed.

(1459) German 480,287 (1929). Metallwerk Plansee, G.m.b.H., *Production of Tungstic or Molybdic Acid.* The desulfurized and concentrated ore is fused and heated so high that pure molybdic or tungstic acid are vaporized and then condensed.

(1460) Swiss 129,580 (1929). Metallwerk Plansee G.m.b.H., *Method of Production of Chemical Pure Coatings.* Metals of the first sub-group of the 6th group of the periodic system are produced by sintering the roasted ore so high that the trioxide vaporizes and upon condensation yields coatings or powder.

(1461) Austrian 116,561 (1930). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Production of Chemically Pure Tungsten- or Molybdenum-Oxide.* Method is based on sublimation of the initial (ore) substance which is mixed with coke.

(1462) French 711,781 (1931). A. Pujoulet, *Metallic Oxides.* Powdered metals suitable for oxidation are obtained by the electrolysis of a bath of sodium ethyl sulfate and a double compound of Na and the metal to be obtained.

(1463) German 521,570 (1931). Metallwerk Plansee G.m.b.H., *Production of Pure Tungstic Acid.* Addn. to German 480,287 (No. 1459). The degassifying and cleaning of WO_3 occurs at a temperature below the melting point of that material.

(1464) U. S. 1,800,758 (1931). P. Schwarzkopf, *Decomposition of Tungsten Ore.* Tungsten ore is subjected to reducing action of carbon or hydrogen and heated to 800° C. (1470° F.), to volatilize MoO_3; upon further heating, at 1300° C. (2370° F.) WO_3 is formed and collected in a condensation chamber.

(1465) U. S. 1,815,132 (1931). P. Schwarzkopf (American Electro Metal Corp.), *Pure Tungsten- or Molybdenum-Trioxide.* Method of production of the trioxide comprises adding C to the primary material, and heat treating in presence of a stream of O_2.

(1466) U. S. 1,816,388 (1931). A. Mittasch, R. Lucas, and R. Griessbach (I. G. Farbenindustrie A. G.), *Producing Finely Divided Metal Oxides.* Method comprises burning a volatile metal carbonyl and a halide of a metallic element distributed in an atmosphere of an oxidizing gas.

(1467) U. S. 1,834,622 (1931). L. G. Jeness, *Treatment of Tungsten Ore.* The pulverized ore is first roasted in a furnace at 700° C. (1290° F.), to cause a cracked mass; then SCl_2 and Cl are passed over the ore, to produce a W compound, soluble in aqueous solution. The residue is treated with Na_2CO_3.

(1468) Austrian 130,611 (1932). Metallwerk Plansee G.m.b.H., *Production of Tungstic Acid.* The evaporation of WO_3 occurs at a temperature below the melting point.

(1469) German 566,948 (1932). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Production of Pure Tungsten or Molybdenum Trioxide.* Addition to German 480,287 No. 1459. Porous material such as charcoal or coke is added to the MoO_3 or WO_3.

(1470) U. S. 2,077,073 (1937). M. L. Ross, *Treatment of Tungsten Ore.* The ground ore is digested with SCl in Cl vapors; treatment of the mass with water results in formation of tungstic acid, which is converted into ammonium para-tungstate by treatment with NaOH.

(1471) U. S. 2,261,371 (1941). A. W. Hixson, *Decomposition of Tungsten Ore.* Finely ground tungsten ore is suspended in water, through which SO_2 gas is bubbled, whereupon the W and Mn go into the boiling solution, with evolution of SO_2; the impure precipitate is digested with HNO_3, yielding pure yellow tungstic acid.

(1472) U. S. 2,347,131; 2,347,132 (1944). R. L. Seabury and R. A. Daily (General Motors Corp.), *Manufacture of Lead Oxide.* Manufacture of litharge ingredient for storage batteries utilizes powdered Pb.

(1473) U. S. 2,351,678 (1944). R. G. Hall, *Extraction of Tungstic Acid.* The pulp ratio in the autoclave is three parts of water to one part of scheelite and Na_2CO_3 is added in an amount of two parts to one part WO_3; the autoclave is maintained at a temperature of 200° C. (390° F.) under pressure of 200 lbs. per sq. in. For precipitation of tungsten as tungstate of iron, $FeSO_4$ is employed.

(1474) U. S. 2,374,454 (1945). T. C. Oliver, R. D. Long, and L. H. Crosson (Charlotte Chemical Laboratories Inc.), *Production of Iron Oxide.* Process comprises treating a solution of $FeSO_4$ with gaseous NH_3 in excess of 6-12% to precipitate the iron oxide; then blowing air through the mass to convert the oxide into a stable, water insoluble form to separate it from ammonium sulfate.

(1475) U. S. 2,381,675 (1945). A. Linz (Climax Molybdenum Co.), *Briquettes for Alloying.* Method of production consists of blowing finely divided metallic oxide selected from the group of oxides of Mo, W or V into a chamber, simultaneously spraying into the chamber a liquified carbonaceous binding material, and then dividing and subjecting the mixture to pressure to form dense briquettes of metallic oxide.

(1476) Brit. 585,294 (1947). Drynamels Ltd. and W. Edwards, *Magnetic Detection of Cracks in Iron or Steel Bars.* A finely divided iron oxide (Fe_3O_4) is prepared from $FeSO_4$ by reaction with Na_2CO_3.

(1477) Brit. 591,941 (1947). Magnesium Elektron Ltd., *Magnesium Oxide.* Highly reactive MgO powder is made by grinding $Mg(OH)_2$ to −250 mesh, and heating to 800-1100° C. (1470-2010° F.).

(1478) Brit. 593,906 (1947). E. Wenger, *Production of Pure Tungstic Acid.* The term tungstic acid includes the product of precipitation of an alkaline earth tung-

state by a mineral acid. Product consists of tungsten anhydride (WO_3) accompanied by its products of hydration ($WO_3 \cdot H_2O$).

(1479) U. S. 2,429,372 (1947). J. A. Savage, *Sintering Furnace for Finely Divided Ore.* A furnace is disclosed for sintering of fine-mesh taconite Fe ore concentrates; to pyritic ore a flux is added.

(1480) Brit. 603,973 (1948). W. K. Jennings, *Treatment of Chromium Ores.* Ores having a Cr to Fe ratio of less than 3:1 are beneficiated by grinding the concentrates so that 80% will pass a 325 mesh-screen, then mixing them with ground bituminous coal, heating the mixture to 1140° C. (2080° F.) with restricted entrance of air, and treating the roasted ore with H_2SO_4.

(1481) U. S. 2,434,048 (1948). G. L. Miller (Murex Ltd.), *Alloy Containing Molybdenum.* Process for producing firm coherent masses of molybdenum oxides which comprises incorporating a small proportion of ammonium molybdate.

(1482) U. S. 2,437,870 (1948). T. J. Williams, *Treatment of Sulphidic Tungsten Ore Concentrates.* Sulfides of Bi and Cu are removed from the scheelite by using a mixture of $NaNO_3$ and pyrolusite as an oxidizing agent.

(1483) U. S. 2,443,254 (1948). W. J. Kroll and F. E. Bacon (Electro Metallurgical Co.), *Separation of Columbium and Tantalum Oxides.* A mixture of Cb_2O_5 and Ta_2O_5 is treated with dry hydrogen at 900° C. (1650° F.) for 1 hour, then a halogenation with gaseous Cl is conducted at 500° C. (930° F.) for a half hour, and the $CbCl_5$ formed is recovered by distillation and condensation.

(1484) Austrian 162,040 (1949). Metallwerk Plansee G.m.b.H., *Cylindrical Furnace with Sloping Axis.* The crucible, for the production of pure molybdic acid, is made of rammed quartz particles.

(1485) Brit. 611,411 (1949). S. A. Pour Les Applications De L'Électricité et des Gaz Rares, Établissements Claudepaz & Silva, *Purification of Tungstic Acid.* Tungstic acid is dissolved in boiling NH_3 solution, and the liquid is filtered hot and concentrated. The ammonium paratungstate crystals are treated in boiling water, filtered and neutralized.

(1486) French 949,137 (1949). Soc. Française Radio-Electrique, *Preparation of Alumina Powder.* Filaments for heating the cathodes of electron discharge tubes may be coated with Al_2O_3 powder, obtained by burning aluminum triethyl with O_2, and separating out the Al_2O_3.

(1487) U. S. 2,474,533 (1949). L. C. Klein (Lake Chemical Co.), *Preparation of Cuprous Oxide.* Mixed CuO and Cu_2O are treated with acetic acid under controlled conditions to dissolve the CuO and form cupric salt of the acid used. The Cu_2O is practically undissolved and may be separated by filtering.

(1488) U. S. 2,477,454 (1949). T. D. Heath (The Dorr Co.), *Process of Reducing Ferric Oxide to Ferrosoferric Oxide.* The ore to be reduced is first converted into a granular or powder form and then fed into a reaction chamber through which the treatment gas passes upward at a velocity controlled with respect to the density and size of the ore particles.

(1489) U. S. 2,477,924 (1949). S. M. Fried and N. R. Davidson (U.S.A., as represented by the U. S. Atomic Energy Commission), *Method of Preparing Uranium Trioxide.* Crystalline UO_3 may be prepared by heating amorphous UO_3 at a temperature between 450 and 750° C. (840 and 1380° F.) in contact with 20 to 150 atmospheres pressure of O_2.

(1490) U. S. 2,491,416 (1949). C. T. Olson and R. W. Hoffman (Fansteel Metallurgical Corp.), *Tantalum Oxide Composition.* Minus 400 mesh Ta powder containing 0.03-0.06% Fe is oxidized by heating on open trays at 625° C. (1158° F.) for 20-26 hours, to yield Ta_2O_5 powder of the same fineness as the Ta powder.

vi. Hydrides (of Titanium, Calcium)

(1491) German 730,329 (1942). Deutsche Gold- & Silberscheideanstalt, *Manufacture of Sodium or Potassium Hydrides.* Hydrides of 100% purity are produced by evaporating Na or K in an electric arc in the presence of H_2.

(1492) Brit. 580,285) (1946). Imperial Chemical Industries Ltd., *Alkali Metal Hydrides.* Sodium hydride is made by agitating a 1.26:1 mixture of Al powder and molten Na at 200-350° C. (390-660° F.) together with up to 1% stearic acid in the presence of H_2.

(1493) U. S. 2,401,323 (1946). P. P. Alexander (Metal Hydrides Inc.), *Production of Metal Hydrides.* A loose mixture of a hydride-forming metal compound and powdered Al is heated in a reaction zone to the melting point of Al, unoxidized molten Al globules are brought into contact with the hydride-forming metal compound, and the resulting reduced metal is distilled and converted into its hydride by admitting H_2 gas.

(1494) U. S. 2,408,748 (1946). P. P. Alexander (Metal Hydrides Inc.), *Production of Lithium Hydride.* A charge of Li_2O and ferrosilicon, while being mechanically mixed, is first subjected to vacuum and then heated in He atmosphere under pressure to a temperature sufficient to distil the resulting metallic Li, which is condensed and contacted with H_2, yielding the hydride formed in the presence of He.

(1495) U. S. 2,411,524 (1946). L. W. Davis (Metal Hydrides Inc.), *Process for the Production of Zirconium Hydride.* The hydride is produced with the aid of Mg powder which is later evaporated from the charge.

(1496) Brit. 585,286 (1947). Imperial Chemical Industries Ltd., *Alkali Metal Hydrides.* Hydride is made by agitating a 1:8 mixture of the molten alkali metal and its hydride at 300-385° C. (570-725° F.) in the presence of H_2 with less than 1% of a hydrocarbon with at least 8 C-atoms in the molecule which acts as activator.

(1497) U. S. 2,427,338 (1947). P. P. Alexander (Metal Hydrides Inc.), *Production of Titanium Hydride.* Invention relates to a mixture of TiO_2 and CaH_2 which is heated to dissociation temperature of the hydride. The alkaline earth metal formed reduces the TiO_2, the metal combining with H to the hydride, which is isolated by leaching the other reaction products with a solvent.

(1498) U. S. 2,427,339 (1947). P. P. Alexander (Metal Hydrides, Inc.), *Production of Zirconium Hydride.* Invention relates to a pyrometallurgical method of producing the hydride.

(1499) Brit. 599,972 (1948). Metal Hydrides Inc., *Production of Metal Hydrides.* A mixture of granulated CaO and Al is heated in a closed retort, previously evacuated and filled with He, to a temperature somewhat above the melting point of Al. The charge is stirred with further heating, and the Ca is distilled and condensed in cooler parts of the retort.

(1500) U. S. 2,450,266 (1948). P. P. Alexander (Metal Hydrides Inc.), *Producing Lithium Hydride.* By heating the anhydrous hydroxide of the alkali metal with the reducing metal in a reaction zone in absence of air to a temperature below the dissociation temperature of the alkali hydroxide.

(1501) Brit. 623,760; 623,761 (1949). The British Thomson-Houston Co. Ltd., *Preparation of Boron Hydrides.* Prepared by passing a mixture of gaseous boron halide and H_2 over finely divided CaH_2, NaH, Al and Mg.

(1502) Brit. 624,458 (1949). Metal Hydrides Inc., *Method of Producing Zirconium Hydride.* ZrO is heated with excess of Mg powder in H_2 and under pressure; the retort is then evacuated until Mg is evaporated, H_2 is readmitted, and the charge is cooled.

(1503) U. S. 2,468,260 (1949). T. R. P. Gibb, Jr. (Metal Hydrides, Inc.), *Method of Producing Lithium Aluminum Hydride and Aluminum Hydride.* LiOH or Li_2CO_3 is transformed to Li_2O, crushed and ground to a fine powder. It is then mixed with Mg-powder and placed in a container in which the air is exhausted and replaced by H_2. It is heated to 600° C. (1110° F.) and H_2 is added to prevent formation of a vacuum. After all H_2 is absorbed, the resultant coarse powder consisting of small friable sinters in the form of small sponges, is cooled.

vii. Others (Halides, Sulfides, Phosphides, etc.)

(1504) U. S. 1,293,402; 1,293,403; 1,293,404 (1919). D. J. Giles and J. E. Giles, *Extracting Tungsten from Ores.* Method comprises a reaction between the ore and a solution of an alkaline compound whose hydroxide radical is replaceable by the metal, forming an alkaline metal solution which is treated with a calcium compound to precipitate a calcium-tungsten compound.

(1505) Brit. 179,201 (1922). W. H. Dyson and L. Aitchison, *Purification of Metallic Ores.* By heating the ore in presence of a halogen, so that the metallic components are volatilized as halogen derivatives.

(1506) U. S. 1,573,083 (1926). J. W. Marden, *Treating Chloride of Tungsten.* A mixture of NaCl and $CaCl_2$ as the reaction agent in a bomb is necessary to reduce the oxychloride.

(1507) U. S. 1,599,618 (1926). W. Koehler, *Process for Forming Metal Compounds.* Producing metallic phosphides from metal powders and powdered phosphorus for use as bearing material.

(1508) U. S. 2,416,191 (1947). W. F. Meister (National Lead Co.), *Purification of Titanium Tetrachloride.* Admixing to the $TiCl_4$ small amounts of an alkali metal hydroxide and powdered Fe, Sn, Zn or Cu and water, boiling the mixture under reflux condition and distilling the $TiCl_4$.

(1509) Brit. 596,576 (1948). Magnesium Elektron Ltd. and R. Sandison, *Purifying Anhydrous Zirconium Chloride.* $ZrCl_2$ is vaporized from a mixture containing 10% ZrS_2, thus removing contaminations of Fe, Al, Si.

(1510) U. S. 2,441,668 (1948). F. C. Mathers and P. S. Visher, *Purification of Magnesium Fluoride for Use as Lens Coating.* MgF_2 is vaporized in a vacuum chamber containing a lens to be coated, after reducing the ferrous compound to Fe, which is removed after cooling.

(1511) U. S. 2,443,253 (1948). W. J. Kroll and F. E. Bacon (Electro Metallurgical Co.), *Producing Zirconium Chlorides.* Method comprises reacting solid $FeCl_2$ and solid Zr-Si alloy above the volatilization temperature of the chlorides of Si or Zr, but below that of ferrous chlorides, to produce a mixture of vapors, and passing them into molten alkali chloride, to dissolve the Zr-chlorides.

(1512) Brit. 627,904 (1949). Säurefabrik Schweizerhall, *Refining of Volatile Metal or Silicon Chlorides.* Crude $TiCl_4$ or $SiCl_4$ is heated in a reflux condenser at subatmospheric pressure to expel the gases, and to facilitate the subsequent stages of refining process.

(1513) Brit. Appl. 8269/49 (1949). A. Johnson & Co., *Production of Pure Zirconium Halides.* The Fe in impure $ZrCl_4$ can be eliminated by subliming at 330° C. (625° F.) in presence of Zn, Mn or Cd.

(1514) Brit. Appl. 10991/49 (1949). E. H. B. Nystrom, *Ferromagnetic Iron Hydroxides.* Purified precipitates from iron salt solutions are spray-dried in N_2 or air; the product does not require ball milling.

(1515) U. S. 2,486,912 (1949). A. Belchetz (Stauffer Chemical Co.), *Production of Titanium Tetrachloride.* $TiCl_4$ can be made in a continuous process by suspending a mixture of powdered rutile or ilmenite and C in a stream of Cl and heating to 650-900° C. (1200-1650° F.).

D. Composite and Coated Powders

(1516) U. S. 304,500 (1884). F. E. Canda, *Manufacture of Solidified Compound Metals.* Manufacture of solidified compound metal comprises dividing into particles two or more metals or alloys with or without fluxes, then coating the particles with a lower melting metal, followed by heating in a die and pressing.

(1517) Brit. 12,381; 12,382/1894 (1894). J. Sachs, *Coating Metal Powders.* Zn powder is kept in agitation by revolving brushes in a cyanide solution of Cu and Zn, contained in a compartment above the brass electrode and under a perforated Pt or C anode, protected by a dialytic partition.

(1518) U. S. 521,992 (1894). J. Sachs and E. Huber, *Process of Manufacturing Metallic Powder.* Metal powder having particles with a core of one metal and a shell of another are made by immersing the cores in a constantly agitated solution of a salt of a metal more electronegative.

(1519) U. S. 522,415 (1894). J. Sachs and E. Huber, *Metallic Powders.* They are produced electrolytically by plating graphite particles with metal, *e.g.* Cu.

(1520) Brit. 173,605 (1922). E. Burden, *Preparation of Aluminum Alloys.* Fused Al is dropped into a solution of $CuSO_4$ and assumes the form of small flakes, each coated with a thin film of pure Cu.

(1521) Brit. 199,958 (1923). A. O. Rodriguez, *Improvement Relating to the Production of Composite Powdered Metals.* Pb filings whose particles are relatively large are mixed with very fine W powder. The mixture is triturated in a ball mill and then submitted to a high pressure and extruded to a thread which is reduced to a coarse homogeneous powder.

(1522) French 741,753 (1932). S. A. Le Carbone, *Metal Powders.* Metal powders suitable for incorporating with C are composed of grains of a cheap metal such as Cu coated with films of non-oxidizable metal such as Ag.

(1523) Brit. 386,499 (1933). Harshaw Chemical Co., *An Improved Manufacture of Metallic Compositions.* Coated powders are produced by electrodeposition and include Sn-plated Cu; they may be subsequently processed by hot-pressing.

(1524) Brit. 396,250 (1933). S. A. Le Carbone, *Metallic Powders.* For electrical contacts, C-powder particles are coated with a non-oxidizable metal like Ag.

(1525) German 587,699 (1933). Hartstoff Metall A. G., *Coating Powder Particles for High Frequency Cores.* The coat consists of a solution of shellac mixed with very fine comminuted fiber, which nestle to the particles during mixing.

(1526) U. S. 1,913,133 (1933). H. H. Stout (Copper Deoxidation Corp.), *Sintered Aluminum, Tin, Zinc, Brass and Bronze.* The powder particles are coated in a bath with Cu; they are then processed by hot-pressing and sintering at recrystallization temperature.

(1527) U. S. 1,986,197 (1935). W. J. Harshaw (Harshaw Chemical Co.), *Metallic Coating of Particles.* A procedure is outlined for electroplating one metal upon particles of a second metal, compressing and heating the plated particles to form an alloy.

(1528) Swiss 181,590 (1936). Duradur A. G., *Coated Carbide Particles for Hard Metals.* WC particles are coated with a metal such as Cr, Ni, Fe, or Cu galvanically or by precipitation from a solution or suspension; the coated powder is then molded and sintered.

(1529) U. S. 2,182,567 (1939). C. L. Mantell (Hardy Metallurgical Co.), *Copper-Coated Lead Powder.* It is produced by plating Cu on particles of Pb using an aqueous solution containing about 100 g./l- Pb-acetate, 50 g./l. Cu-acetate and 15 g./l. acetic acid at a cathode current density of about 17.6 amp./sq. ft.

(1530) Brit. 521,051 (1940). Johnson Bronze Co., *Oxide-Coated Particles.* Powdered metals having oxide-coated particles are mixed with finely powdered metals or reducible metal compounds, followed by sintering the mixture in reducing atmosphere and pulverizing the sintered mass.

(1531) German 687,164 (1940). H. Welte, *Coated Metal Powder Particles.* Pb, Zn or Al powder is coated electrolytically with Cu, to be suitable for pressing with synthetic resin powder into articles for electrical purposes.

(1532) German 698,478 (1940). Hardy Metallurgical Co. and C. L. Mantell, *Electrolytic Production of Lead Powder Coated with Copper.* The electrolysis occurs at high current density in presence of a solution of a Cu compound, by using soluble Pb- and Cu-anodes.

(1533) U. S. 2,216,769 (1940). J. E. Drapeau, Jr. and L. G. Klinker (Glidden Co.), *Metal Powder.* C-coated Cu-powder, comprising discrete particles of metal powders carrying coatings of undiffused amorphous C, are produced.

(1534) U. S. 2,253,476 (1941). R. T. Wirth, *Production of Composite Powders for Hard Cutting Tools.* Method comprises contacting and stirring particles of preformed hard metal carbide with a non-ferrous molten bath containing Co and the metal of the carbide, retaining particles of the preformed carbide in a sintered condition in association with the molten bath, and casting the mixture to obtain sintered particles covered by the matrix material.

(1535) U. S. 2,261,425 (1941). C. Wentworth (Radio Corp. of America), *Paramagnetic Material.* Method of making paramagnetic particles of curved contour comprises dropping separate molten particles of magnetic material, such as partially oxidized Fe or Ni powder, into flaming alcohol.

(1536) U. S. S. R. 58,769 (1941). V. D. Romanov, *Hard Alloys.* Absorption of C by the binding metal (Fe filings) in the powder metallurgy process is prevented by coating the particles of C or the binder metal or both with a metal that prevents diffusion of C (*e.g.* Ag) in the case of WC.

(1537) Belgian 447,443 (1942). I. Rennerfelt, *Shaped Objects from Iron and Other Metals.* Metal grains are partially decarburized and oxide-coated. On sintering the C still present reduces the film of oxide.

(1538) Canadian 436,587 (1942). Aluminum Co. of America, *Coated Magnesium Powder.* Mg powder is coated with a Cr-compound for greater safety in handling.

(1539) German 717,881 (1942). K. Daeves, *Production of Non-Homogeneous Metal Bodies.* The metal particles are changed on their surfaces by diffusion of other materials, prior to sintering. Cr-coated Fe particles are an example.

(1540) German 718,170 (1942). Gesellschaft für Elektrochemische Industrie G.m.b.H., F. X. Schwaebel and Dr. Alexander Wacker, *Method for the Production of Copper-Containing Lead Powder.* Cu-coated Pb powder is produced by the reaction of water soluble Cu salts of inorganic acids with Pb powder in the presence of auxiliary metal, *e. g.* Zn or Fe, which combines with the acid residue of the Cu salt and forms easily water soluble compounds.

(1541) U. S. 2,273,832 (1942). E.P. Carney (Metals Disintegrating Co.), *Method of Making Metal Powders.* Metal powders having particles with a core of a high melting point metal, *e.g.* Cu and a coating of a lower melting metal, *e.g.* Sn are produced by providing a temporary bond between the coating and the core with the aid of moisture, or by an adhesive, or by electrochemical deposition.

(1542) U. S. 2,286,237 (1942). J. D. Shaw and W. N. Revock (Metals Disintegrating Co.), *Coated Copper Powder.* Particles of Cu have a surface alloy coating of Cu mixed with 0.2-1% of another metal such as Zn and Pb which are more electropositive.

(1543) U. S. 2,289,897 (1942). C. C. Balke and K. Misegades (Fansteel Metallurgical Corp.), *Ferrous Powder Metallurgy.* Metal powders for the conversion into steel bodies are made by providing a steel powder having a slightly greater C content, than desired in the finished steel body, and plating onto the steel powder a layer of Fe, to bring the C content of the composite body down to the desired figure.

(1544) U. S. 2,294,895 (1942). J. E. Drapeau, Jr. and C. R. Rogers (Glidden Co.), *Copper Powder.* Cu powder of improved stability for manufacture of pressed shapes contains from 0.05-0.3% Sn distributed as fine films upon the surface of the Cu particles.

(1545) U. S. 2,303,504 (1942). C. J. Ryan (E. I. Du Pont de Nemours), *Rendering Metal Powders Tarnish-Resistant.* Particles of lammellar disintegrated bronze powder are coated with a partially polymerized urea-formaldehyde aliphatic monohydric alcohol condensation product by polishing at an elevated temperature not exceeding about 63° C. (145° F.).

(1546) Brit. 556,197 (1943). Berk & Co., Ltd. and H. W. Jones, *Manufacture of a Substance in Powder Form.* A compound containing Pb and C, suitable for the manufacture of bearings, is produced in powder form by heating Pb-acetate or other organic salts of Pb in non-oxidizing atmosphere to decomposition temperature.

(1547) Brit. 575,449 (1946). Mallory Metallurgical Products Ltd., *Refractory Metal Composition.* Refractory metal particles of carbides or borides of W or Mo are coated with a layer of a metal of the Pt group.

(1548) U. S. 2,398,517 (1946). W. W. Castor, *Apparatus for Plating Finely Divided Material.* Apparatus for coating finely divided particles with metal comprises a chamber, air evacuation means, means for generating a metal vapor in the chamber and means for holding and sifting finely divided solid material into the vessel to cause it to fall through the vapor.

(1549) U. S. S. R. 69,628 (1947). E. I. Khazanov and D. M. Ghizhikov, *Light Metals.* The vapor mixture of the reduced metal oxides are sprayed with a molten high-boiling metal, *e.g.* Sn or Pb, to produce a rapid cooling, which prevents the re-oxidation of the powdered metal.

(1550) Brit. 597,394 (1948). C. F. Lumb, *Method of Coating Surfaces.* Mg alloy powder is flame-sprayed with Zn or Fe under the following conditions: Mg alloy particle size is -90 + 200 mesh, flame temperature is 350° C. (660° F.), and air pressure is 20-30 lb./in.^{2}

(1551) Brit. 598,181 (1948). Diffusion Alloy Ltd. and R. L. Samuel, *Process for Coating Metal Powders.* Metal powders are coated with another metal by diffusion of the latter from its gaseous chloride, which may be produced *in situ.* Cr-coated Fe powder is an example.

(1552) U. S. 2,445,155 (1948). A. J. Sankaitis (American Chemical Paint Co.), *Protective Coating for Cupriferous Surfaces.* The surface of Cu particles is made corrosion resistant by treatment in a solution of $ZnCrO_4$, which after treatment is dried without rinsing; the surface coated particles may be used as base for paints.

(1553) Brit. 617,975 (1949). G. Malecki, *Method of Producing Iron Powder.* The non-rusting properties of the Fe powder, produced by reduction in an inclined rotary furnace with cracked methane or coal gas above the minimum reduction temperature, are obtained by formation of coatings on the particles by means of a siliconizing, aluminizing, or nitriding process.

(1554) Brit. Appl. 8047/49 (1949). Ekstrand & Tholand, Inc., *Metal Powder for Metallurgical Operations.* Fe powder is coated with Cu, or Ni, and then subjected to a heating, to promote the partial diffusion of the coating. A Cu-Ni coating is obtained by coating first with 4% Cu and then with 2% Ni.

(1555) U. S. 2,483,075 (1949). E. C. Truesdale (The New Jersey Zinc Co.), *Method of Copper Coating Iron Particles.* The inclusion of a small amount of $CuCl_2$ in a mixture of Fe powder and oxidized cuprous material materially aids the complete envelopment of the Fe particles in a continuous coating of the reduced cuprous material.

E. Semi- and Non-Metal (and Compound) Powders (Carbon, Boron, Silicon)

(1556) U. S. 1,030,327 (1912). H. N. Potter (George Westinghouse), *Carbosilicon.* Powdered carbosilicon is produced from SiC and Si.

(1557) Brit. 434,461 (1935). F. Krczil, *Active Carbon.* Powdered C is pressed and baked.

(1558) U. S. 2,349,697 (1944). N. R. Bierly (American Metal Co.), *Art of Producing Selenium.* Se powder is produced by eliminating impurities from Se-containing solution.

(1559) U. S. 2,414,294 (1947). D. Gardner, *Production of Pure Tellurium.* Method comprises passing the impure Te-containing material through an indirectly heated furnace, having zones wherein the material is subjected to a selective distillation, and vaporizing the Te at a temperature below that at which the higher melting impurities are vaporized.

(1560) U. S. 2,415,946 (1947). W. Goss, *Method of Making Boron.* Powdered elemental B is produced by using gaseous BCl_3 which is introduced inside an electric furnace into a gaseous suspension of powdered B and reduced.

(1561) Brit. 601,430 (1948). Standard Telephone & Cables Ltd., *Material for Semi-Conductors.* Material for selenium rectifiers is made by subliming 0.005-1% of one or more of the halogen compounds ICl, IBr, ICl_3, IBr_3, on the Se powder.

(1562) Brit. 604,040 (1948). Joseph Lucas Ltd., H. Silman, A. Freeman and H. S. Joachim, *Material for Electric Current Rectifiers.* Se powder is treated with 0.1-1% of the Na salt of a halogenated aryl sulphonic acid.

(1563) U. S. 2,469,418 (1949). M. M. Striplin, Jr. (Tennessee Valley Authority), *Producing Silicon* The improvement comprises cold crushing to a coarse powder the crystalline Si and an Al-Si alloy in eutectic proportion, screening the coarse powder, thereby separating it into a relatively coarse fraction free from crystalline Si, and a fine fraction rich in crystalline Si, and separating the high purity Si from the fine fraction.

II. Powder Processing Methods and Equipment

1. POWDER TREATMENTS

A. Separation (Selection, Classifying, Refining)

(1564) U. S. 194,797 (1877). A. Work, *Magnetic Ore Separator.* Magnetic ore separator for separating brass filings from iron and steel cutting tool particles is disclosed.

(1565) U. S. 1,345,835 (1920). G. Clement (Clement Gold Magneto Co.), *Apparatus for Electrically Separating Finely Divided Metals from Other Pulverized Materials.* Apparatus comprising a hopper and electrical condenser is claimed.

(1566) U. S. 1,826,583 (1931). C. Thurneyssen (S. A. Le Nickel), *Process of Metallurgical Treatment.* Fe is removed from a less readily oxidized metal by atomizing the alloy, heating it thereby oxidizing the Fe, and treating the resulting powder to remove the oxide by mechanical separation. The process is repeated and pure metal is separated.

(1567) Brit. 483,458 (1938). I. G. Farbenindustrie A. G., *Preparation of Metal Powders For Electrical and Magnetic Purposes.* Wind sifting of dust from decomposed Fe and Ni-carbonyls has the purpose of improving the magnetic properties.

(1568) Brit. 487,232 (1938). Haardt & Co., *Apparatus and Method for Determining the Grain Size and Grain Size Range of Powdered Materials.* A powder is suspended in and deposited from a fluid, having a specific gravity or viscosity giving a convenient rate of deposition and having a dielectric constant different from the powder.

(1569) French 827,430 (1938). I. G. Farbenindustrie A. G., *Preparation of Metal Powders for Electrical and Magnetic Uses.* Preparation of metal powders for electric or magnetic uses, such as cores,comprises decomposition of Fe-carbonyls, followed by separating the metal powders into fractions with different grain sizes by subjecting the powder to a treatment of wind sifting.

(1570) German 668,186 (1938). W. Dawihl and K. Schröter (Patent-Treuhand-Ges.), *Centrifuging of a Chemically Uniform Powder into Uniform Grain Sizes.* Subsieve size powders are graded by centrifuging in a fluid which makes stationary sedimentation difficult.

(1571) U. S. 2,125,870 (1938). F. C. Arthur and J. B. Barnitt (Aluminum Co. of America), *Treatment of Aluminum Bronze Powder.* Air separation for the production of a very fine aluminum bronze powder results in such size and quality that 98.5% of the powder will pass through a screen having 325 openings to the lineal inch.

(1572) Belgian 443,079 (1941). Metallgesellschaft A. G., *Electrostatic Separation of Powders.* The powder falls through a humid atmosphere to precipitate water vapor on the particles for the subsequent electrostatic separation.

(1573) Brit. 532,546 (1941). United States Rubber Co., *Classification of Mixed Materials.* Method employs depositing the material to be graded on an elastic sheet containing perforations, and gradually stretching the sheet to progressively enlarge the perforations, whereby the material is sifted.

(1574) German 713,929 (1941). Robert Bosch G.m.b.H., *Classifying.* Before sedimentation powder of −100 μ is disposed in a liquid that is exposed to ultrasonic vibrations.

(1575) U. S. 2,293,843 (1942). J. T. Marvin (General Motors Corp.), *Method of Making Porous Articles.* A method wherein the disposition of metal powders of varying grain size is accomplished by a vibratory type of segregation produced either by mechanical or electrical means.

(1576) U. S. 2,325,881 (1943). M. Robertson, *Recovery Apparatus.* A device for separating particles of different densities, such as for recovering fine Au from sand, is disclosed.

(1577) U. S. 2,328,240 (1943). E. L. Wiegand (Orefraction Inc.), *Processing of Materials.* In a system of grinding hard metals and abrasives to 200 mesh size a device is provided for classifying the particles.

(1578) U. S. 2,331,769 (1943). S. G. Frantz, *Magnetic Separator.* A magnetic separator for removing Fe particles from a stream of dry material is claimed.

(1579) U. S. 2,336,470 (1943). C. W. Davis, *Separation of Materials.* A method of separation of powdered metals of different specific gravities employs a mixture of a magnetic material containing Pb.

(1580) Brit. 562,210 (1944). Russell Construction Co., *Sifting Apparatus.* Sieves are mounted in such a way as to be capable of a rapid circular or gyratory movement of small amplitude in the plane of the sieving surface under the influence of a rotating out-of-balance weight.

(1581) U. S. 2,338,501 (1944). B. S. Followill and A. R. MacLean (Western Electric Co.), *Magnetic Separation.* Magnetic separation for precious metal particles comprises a continuous moving belt on a horizontal bed onto which contacts are deposited and a pair of spaced pole pieces mounted in a magnetic circuit.

(1582) U. S. 2,343,803 (1944). A. E. Rothgarn, *Apparatus for Dry Separation of Heavy Minerals.* An apparatus for dry separation of heavy mineral particles such as Au functions on broken up ore material.

(1583) U. S. 2,348,479 (1944). I. F. Kellerman, *Ore Separating Apparatus.* An ore separating apparatus, especially adapted for use in separating Au or other heavy metals from crushed ore, is disclosed.

(1584) U. S. 2,356,717 (1944). R. W. Williams (Standard Oil Developing Co.), *Recovery of Finely Divided Metals.* Separation and recovery of suspended particles such as powdered catalysts from vapors or gases comprises adding NH_3 and subjecting to electrostatic separation.

(1585) U. S. 2,371,665 (1945). J. Wulff, *Process of Classifying Metal Powders.* A method of producing classified Fe powder which comprises forming a white cast Fe shot, disintegrating the shot to a powder to form C-rich and C-poor components, and magnetically separating the particles above the Curie point of the C-rich particles.

(1586) U. S. 2,372,321 (1945). W. E. Griffiths (Allegheny Ludlum Steel Corp.), *Apparatus for Separating Stainless Steel.* An apparatus is claimed for separating stainless steel particles from abrasive particles employed in grinding operations.

(1587) U. S. 2,393,160 (1946). O. E. Harder and A. E. Pavlish (Pittsburgh Crushed Steel Co.), *Separation of Ores and Metals.* Suspensions of finely divided Fe-C alloy in water contain a corrosion-inhibitor used in heavy media separation process.

(1588) U. S. 2,398,792 (1946). H. B. Johnson, *Electrostatic Sizing of Materials.* An electrostatic process of separating fine powdered material comprises classifying according to their differences in specific gravity, magnetic permeability, electrostatic susceptibility, or particle shape.

(1589) Brit. Appl. 26487/47 (1947). Carlfors Aktiebolag and K. G. Winquist, *Sizing of Aluminum Powder.* Al flake powder is classified according to a preferred specific surface and size by using a cyclone separator with an adjustable gas supply, taken off from behind the main fan to a radial point on the level of the tangential inlet.

(1590) Brit. Appl. 34520/47 (1947). D. Primavesi, *Purification of Magnetic Powders.* An upper and a lower conveyer belt are exposed to a magnetic field, and an alternating magnetic field is superimposed on the magnetized section of the upper conveyer belt, thereby effecting separation of magnetic from non-magnetic particles.

(1591) U. S. S. R. 68,384 (1947). M. A. Netsvetaev and A. V. Stukachev, *Separation of Mixtures.* A mixture of powdered ferromagnetic materials is heated until one of the components loses its magnetic properties; then the mixture is separated magnetically.

(1592) U. S. 2,441,479 (1948). H. F. Fisher (Union Oil Co. and Permanente Metals Corp.), *Apparatus for Cataphoretically Treating a Liquid Suspension.* A device is disclosed for separating two-phase systems consisting of conducting solids dispersed in a non-conducting fluid, to obtain a concentrated solid phase and a clear liquid phase; an example is the concentrating of Mg dust in a hydrocarbon medium.

(1593) U. S. 2,448,848 (1948). W. F. Van Loenen (Permanente Metals Corp.), *Electrophoretic Separating Apparatus.* The apparatus comprises a horizontally disposed rotary drum, constituting the one pole, and an anode in the drum as the second pole, producing a film out of a metal powder-containing slurry, which moves upward during rotation.

(1594) Brit. 624,103 (1949). Comp. De Produits Chimiques et Electro-Métallurgiques Alais, Froges & Camargue, *Magnetic Separation of Very Fine Pulverulent Products.* Minus 250 mesh powder of magnesia is screened by vibration in a vertical retort containing a rotating electromagnet from which magnetic metallic particles are removed by brushes.

(1595) French 941,413 (1949). Pluro, Inc., *Electromagnetic Separator.* Separator is claimed in conjunction with metal oxide reduction process claimed in French Pat. 941,412 (No. 952).

(1596) U. S. 2,474,059 (1949). F. C. Morton, *Inclined Current Hydraulic Separator.* The separator is applicable to a wide range of granular materials, both mineral and metallic.

(1597) U. S. 2,479,141 (1949). F. E. Smith (E. I. du Pont de Nemours & Co.), *Annular Horizontal Current Gravity Liquid Classifier.* Invention provides a continuous three-part separation of solids of different specific gravities by the use of a parting fluid which is circulated in a circular trough and to which a plurality of feeds are simultaneously fed. Each of the separations, *i.e.*, floats, middlings and sinks, are separately removed from the separator and respectively delivered to stations for further treatment as necessary.

(1598) U. S. 2,479,615 (1949). R. L. Guizzetti, *Amalgamator, Including Electrical Precipitation Means.* An apparatus for separating precious metal particles from ore comprises a hopper having a bottom opening, and a pair of parallel vertical plates, separated by a small gap and positioned below the bottom opening; a high electrical potential is produced between the plates.

(1599) U. S. 2,480,732 (1949). L. G. Hendrickson (Hudson Bay Mining & Smelting Co., Ltd.), *Filter Apparatus for Purifying Fluids.* Apparatus is applicable for the removal of dissolved metal impurities from $ZnSO_4$ solutions by precipitation on Zn dust. Apparatus comprises an assembly of alternately positioned plates and frames, with a filter interposed between each side of each frame and the adjacent plates.

(1600) U. S. 2,484,203 (1949). J. H. Beck, *Oscillating Placer Separating Machine.* The housing of machine is bifurcated and hollow and has a pair of hollow arms secured to the bottom of a pan having openings and mounted for oscillation about a vertical axis. Au particles are separated from sand by the vibration, and are discharged through the hollow arms.

(1601) U. S. 2,485,128 (1949). E. W. Adams (The Permanente Metals Corp.), *Pelleting Magnesium Dust.* Occluded gases are removed from Mg dust comprising a mixture of Mg, MgO and C with concomitant impurities characterized by fine particle size, low bulk density and occluded gas, by subjecting the dust to centrifugal separation. It is then fed to a pelleting station while compacting the dust to further expel gas and thus induce agglomeration.

(1602) U. S. 2,487,272 (1949). W. G. Price, *High-Frequency Electric Separator.* An electrical apparatus provides for separating non-magnetic particles of Au, Ag or Cu from non-magnetic particles such as ground rock or sand.

B. Combination (Mixing, Blending, Coating, Adding of Agents)

(1603) German 194,468 (1908). Siemens & Halske A. G., *Plastic Mass of Tungsten Compounds.* Ammonium-tungstate is heated in a dry state, to drive off NH_3; then the heated mass is mixed with water to produce a paste.

(1604) Brit. 29,691/1909 (1910). P. Claes, *An Improved Process for Agglomerating Small Fragments of Metals, Minerals and Combustibles.* Material is mixed with lime and water and placed in a container in which vacuum exists. Then carbonic acid is introduced and the substance is heated.

(1605) U. S. 1,065,855 (1913). L. Weiss, *Manufacture of Alloys.* The particles of one metal are embedded in an agglutinant and then mixed with a coarsely comminuted second, refractory constituent; the melting point of the agglutinant exceeds that of the refractory constituent.

(1606) German 272,347 (1914). Dick, Kerr & Co. Ltd., *Binder for Tungsten Filaments.* Consisting of Na-silicate, which is mixed with the tungsten powder.

(1607) Brit. 15,961/1914 (1915). British Thomson-Houston Co. Ltd., *Manufacture of Workable Tungsten Bodies.* An agglomeration for use in the manufacture of workable W bodies consists in making a mixture of different varieties of pure W powder derived from different chemical compounds of W.

(1608) German 363,128 (1922). A. Müller, *Production of Metals.* Metal particles of different melting points are mixed with colophony and NH_4Cl, then heated till the lower melting particles are fused.

(1609) German 399,774 (1924). A. O. Rodriguez, *Alloy of Metals of Different Hardness.* Greater particles of the soft metal are mixed with smaller particles of the hard metal till a complete permeation is attained, whereupon the non-consumed hard metal particles are separated by sieving; then the mass is heated for alloying.

(1610) U. S. 1,566,793 (1925). W. B. Gero (Westinghouse Lamp Co.), *Comminuted Tungsten or Other Refractory Metals.* Particles are mixed and coated with paraffin dissolved in ether prior to sintering.

(1611) U. S. 1,631,493 (1927). C. A. Laise, *Treatment of Tungsten Powder.* Tungsten powder is combined and ball-milled with B-nitride.

(1612) Austrian 109,852 (1928). K. Bergl, *Production of Pseudo-Solutions.* Method comprises making the pseudo-solutions in ball-mills rotating so that the velocity of rotating the balls is smaller than their velocity of falling, to subject the particles in the mill only to shearing forces.

(1613) Brit. 313,619 (1929). Fried. Krupp A. G., *Preparation of Tungsten-Carbide Powders for Tools.* A pulverulent starting material is mixed with a binding medium capable of setting or hardening, so that the pressed body is not plastically altered in shape, but, after the added binding medium hardens, can be worked mechanically into final form and sintered.

(1614) Dutch 26,590 (1929). Allgemeine Elektrizitäts-Gesellschaft, *Powder Preparation for Sintered Hard Metals.* An organic compound is admixed to the raw material before pressing of hard metals; the compound evaporates during sintering.

(1615) Swedish 70,514 (1929). Fried. Krupp A. G., *Powder Preparation for Hard Metal.* The powder is mixed with paraffin etc. During drying the mixture solidifies, and can then be pressed and sintered.

(1616) Brit. 337,160 (1930). Metallgesellschaft A. G. and J. Gray, *Tungsten Powder Preparation for Ingots.* Production of tungsten ingots by compacting and sintering is facilitated by the elimination of residual O, achieved by intimately admixing a powder of a more volatile metal which forms an unstable compound with O.

(1617) Canadian 305,425 (1930). Canadian Westinghouse Co. Ltd., F. H. Driggs and W. C. Lilliendahl, *Treatment of Rare Refractory Metal Powders.* Refractory metal or carbide powders, such as Ta or TaC, are treated to form coherent workable bodies by admixing therewith a proportion of any O-compound of the refractory metal in amounts insufficient to react with the whole of the C content thereof; then the mixture is compressed and heated in vacuum.

(1618) French 699,811 (1930). I. G. Farbenindustrie A. G., *Powder Treatment by Adding a Liquid.* The powder is mixed with a molten or dissolved compound, followed by solidifying, heating and sintering, whereby the compound is simultaneously reduced.

(1619) Swiss 139,552 (1930). Fried. Krupp A. G., *Powder Preparation for Hard Metal. Cf.:* Swedish 70,514 (No. 1615).

(1620) French 701,064 (1931). I. G. Farbenindustrie A. G., *Molding Powdered Metals.* In molding powdered metals such as Fe without fusion, impurities are removed by addition of substances such as Al or $MnCO_3$ capable of forming slags with the impurities.

(1621) French 703,960 (1931). Comp. Francaise Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Compositions.* Prevention of grain growth during sintering is achieved by the addition of ThO_2.

(1622) French 708,833 (1931). Fried. Krupp A. G., *Milling of Hard Metal Powder.* The hard metal and binder metal powders are mixed with methylene chloride as suspension in a non-oxidizing liquid.

(1623) German 531,921 (1931). Fried. Krupp A. G., *Method for Wet-Milling of Powders of Hard Metal.* To the powdered mixture is added a non-oxidizing fluid, *e.g.* methylene chloride.

(1624) Swedish 74,022 (1931). Fried. Krupp A. G., *Hard Metal Alloy.* The hard metal powder is mixed with methylene chloride before sintering.

(1625) Brit. 376,242 (1932). Fried. Krupp A. G., *Wet Ball Milling Hard Metal Powders.* A wet ball milling process for making a homogeneous hard metal powder mixture consists of using a liquid which has no oxidizing action and evaporates at low temperature.

(1626) German 555,228 (1932). Patent Treuhandgesellschaft für Elektrische Glühlampen, H. Wolff, and K. Schröter, *Preparation of Powders and Making Tools With Sharp Cutting Edges.* Refractory metal powders are mixed with dextrine lacquer, or shellac, pressed till the binding agent is solidified, then worked and sintered.

(1627) Swiss 150,995 (1932). Fried. Krupp A. G., *Wet-Milling of Hard Metal Mixtures.* The powder is mixed with a non-oxidizing and decomposed vaporizing fluid, *e.g.* acetone, benzene.

(1628) U. S. 1,856,607 (1932). R. Walter, *Production of Sintered Alloys.* Moist metal powders or metallic aggregates are mixed with plant oil, and then pressed, hardened and sintered.

(1629) Brit. 408,716 (1934). G. Sterky and K. M. Tigerschiöld, *Obtaining Coherent Masses From Powdered Metals.* A mixture of powdered metals and chemicals that attack the surface facilitates compaction and increases cohesion.

(1630) Swiss 169,094 (1934). Fagersta Bruks A. B., *Production of Hard Metal Bodies Exposed to Wear and Tear.* A conventional hard metal mixture is agitated with NH_4Cl, $(NH_4)_2SO_4$ or NaCl, which affect the surface of the auxiliary metal particles, to produce a good binding, prior to sintering.

(1631) U. S. 1,979,372 (1934). E. Dühme and E. Cremer (Deutsche Edelstahlwerke A.G.), *Method of Making Hard Bodies.* 1% glycerine is admixed to facilitate compacting of hard metal powder.

(1632) U. S. S. R. 36,651 (1934). A. A. Abinder and L. P. Mol'kov, *Preparation of Articles From Hard Alloys.* Carbides are powdered, mixed with a solution of the cementing substances in organic solvents, then processed.

(1633) German 624,166 (1935). Hartstoff Metall A. G., *Insulation of Ferromagnetic Particles.* A small quantity of fat or oil is mixed so homogeneously with the powder that the particles are coated, then the powder is mixed with an alkali solution, which acts as insulation after drying.

(1634) Swedish 87,859 (1936). Fagersta Bruks A. B., K. M. Tigerschiöld, and G. L. T. Sterky, *Method of Making Hard Alloy For Tools.* A Cl-containing compound, *e.g.* NH_4Cl is admixed to Co, Ni, Fe-coated particles of refractory carbides, borides, nitrides, silicides to promote reaction during pressing.

(1635) German 648,636 (1937). Fried. Krupp A. G., *Powder Preparation for Sintered Alloys.* Salts of organic acids like acetates are added to facilitate subsequent sintering.

(1636) Swiss 201,863 (1937). A. Korek, *Mixture of Metal Powders.* One metal powder is atomized and caused to rise, and the other ingredients are sieved, thereafter falling and mixing with the rising dust.

(1637) U. S. 2,082,354 (1937). R. Reichmann (American Cutting Alloy Inc.), *Method of Making Sintered Shaped Bodies.* The powdered carbides and cementing metals are mixed with H_2O, glycerol and Co-nitrate to form a suspension.

(1638) Brit. 481,805 (1938). W. H. Hatfield and B. Holdon, *Manufacture of Hard Alloys.* Mixture of carbides and oxide of bonding metal are rotated in a barrel to smear the oxide over the carbide particles.

(1639) Brit. 491,415 (1938). Robert Bosch G.m.b.H., *Process to Improve the Pressing Metal Powders.* Improving the compressibility of powdered mixtures consists of using the softer metal in the form of a powder of which the volumetric weight is smaller than the volumetric weight of the harder powder.

(1640) Swiss 197,352 (1938). A. Korek, *Sintered Hard Metal Alloys.* The metal powders are mixed by sieving.

(1641) U. S. S. R. 53,329 (1938). W. W. Karetnikow, *Bearing Metal.* The metal powders are mixed with glycerine and litharge before pressing and sintering.

(1642) German 673,505 (1939). F. Skaupy, *Compact Metal Bodies.* Halogens are admixed to powders from metals such as Al, Mg or Zn, which form oxides difficult to reduce, in the production of compact sintered metal bodies.

(1643) German 673,558 (1939). Follsain Syndicate Ltd., *Powder Mixing Treatment for Alloys of Iron or Nickel.* In the production of alloys with Ni or Fe as basic metal, the constituents which easily oxidize are mixed together with metal salts and alcohol to form a paste, and then the paste is mixed with the basic metal.

(1644) German 677,996 (1939). Robert Bosch G.m.b.H. and E. Dorn, *Method for Improving Compressibility of Mixed Powders.* Method is especially suitable for production of porous bearings of Fe mixed with a plastic metal, *e.g.* Cu, Al, Sn, and comprises using the plastic metal phase in form of a powder whose specific loading weight is smaller than that of the powder of the more brittle metal phase.

(1645) German 680,359 (1939). Siemens & Halske A. G., *Method for Inhibiting the Sintering of Magnetic Powders.* Method for the inhibition of the sintering of magnetic powders during annealing comprises mixing the powder with $CaCO_3$ which is washed out after annealing.

(1646) U. S. 2,150,671 (1939). F. K. Bezzenberger, *Process of Making Composite Metal Articles Such As Alloys Containing Dispersed Graphite.* Production of composite metal articles comprises mixing at elevated temperature a finely divided non-alloying metal with a non-ferrous metal and hereby permitting the temperature of the mixture to fall to a level below the solidus state of the metal; then reheating the resulting granular mixture to a temperature within its "bi-phase temperature range" and then pressing it.

(1647) U. S. 2,173,100 (1939). J. E. Drapeau, Jr. and J. O. Johnstone (Glidden Co.), *Preparation of Metal Powders for Brushes, Contacts, Bearings by Admixing Lubricant.* A dry, non-segregating, free-flowing metal powder mixture of 90% Cu and 10% Sn is mixed with a liquid non-reactive with the metal powder, such as

kerosene, in a quantity of 0.03%; the liquid evaporates slowly and remains in the powder during storage.

(1648) German 688,269 (1940). Deutsche Gold- & Silberscheideanstalt. *Method of Producing Metal Bodies.* Metal powders are mixed with hydrides, followed by heating and pressing the mixture.

(1649) German 704,463 (1941). H. Franssen and W. Dawihl (Fried. Krupp A. G.), *Objects Produced From Hard Metal Powders by Means of Vibratory Mixing.* Comprises agitating the powders during mixing by ultra-sound vibrations.

(1650) U. S. 2,246,165 (1941). W. Dawihl and H. Franssen (General Electric Co.), *Method of Powder Preparation for Sintered Hard Metal Bodies Such as Those for Tools.* W mixtures are agitated by supersonic oscillations to accomplish mixing before pressing.

(1651) U. S. 2,336,438 (1943). A. C. Evans (Scovill Manufacturing Co.), *Apparatus for Mixing Powdered Materials of Different Specific Gravities Such as Explosives or Burning Powders.* A mixing machine subjects powdered materials in receptacles to a series of alternately reversing sliding and partial rolling action to prevent separation of mixed ingredients.

(1652) German 746,648 (1944). M. Baermann, *Production of Homogeneous Ferromagnetic Mixture.* Homogeneous mixture of magnetic and non-magnetic particles of different gravity are claimed to be obtained by mixing them in a magnetic field.

(1653) U. S. 2,368,458 (1945). E. W. Engle (Carboloy Co.), *Method of Making Thin-Walled Sintered Metal Articles.* Metal powders, and especially cemented carbides powders are mixed with oil to form a paste, which is spread in a mold and sintered.

(1654) U. S. S. R. 64,304 (1945). R. K. Burshtein and M. V. Pavlova, *Preventing the Oxidation of Finely Divided Metals.* Finely divided metals are immersed in an organic solvent, filtered and dried; the vapors of the solvent can be passed through the metal.

(1655) U. S. S. R. 64,664 (1945). I. A. Alekseev, *Sintered Alloys.* Chalk is added to a dry mixture which at the temperature of sintering liberates CO_2 and allows combining with C to form carbon-black. This obviates the necessity of using H_2 for a reducing atmosphere.

(1656) U. S. 2,405,278 (1946). C. L. Vance (Ohio Ferro Alloys Corp.), *Powder Preparation for Ferro Alloy Briquettes.* Finely crushed ferroalloys are mixed with larger particles of the material and with 3 to 5% hot tar or pitch and molded at 2 tsi. The strength of the briquettes is increased by adding to the mixture before briquetting strips of paper, leather shavings, etc.

(1657) Austrian 162,874 (1949). Metallwerk Plansee G.m.b.H., *Increase of Strength of Strands of Metal Powders During Pressing.* To the pasty mass of metal powders is admixed 0.05-3% of organic fibrous material, *e.g.* cellulose or artificial silk.

(1658) Brit. 626,983 (1949). F. W. Berk & Co. Ltd., and W. D. Jones, V. E. Yarsley, D. F. Mordant, *Metallic Castings.* Metal powder is mixed with 25% of a liquid monomer containing a polymerization catalyst and a plasticizer. The mixture is poured and set by heating to promote polymerization.

C. Deformation (Ball-Milling, Strain Hardening)

(1659) Brit. 204,055 (1924). Hartstoff-Metall A. G., *Manufacture of Lamelliform Metal Powders.* Flattening the particles to the required extent is accomplished by treating the powder particles by pressure, produced by a striking or rolling effect, between tools having elastic working faces, which touch each other without intermediate spaces.

(1660) Brit. 293,609 (1928). Hartstoff-Metall A. G. and E. Kramer, *An Improved Metal Powder and Method of Producing Same.* Various kinds of dense metal powder

of small laminar granules are produced by bending leaf-shaped particles in a machine until the edges are bent upward, and continuing the treatment until hollow spheres result.

(1661) German 459,595 (1928). Hartstoff-Metall A. G., *Rounding of Particles.* Method of rounding particles is based on a whirling circuit (eddy) mill with a casing and rotating beaters, which exert during the feed a pressure and a friction on the particles to force them through repeated cycles for mixing and rounding the particles.

(1662) German 471,310; 479,337 (1929). Hartstoff-Metall A. G., *Rounding of Particles.* Method for rounding of particles of metal powders in whirling circuit (eddy) mills according to German 459,595 (No. 1661) comprises exerting a pressure on the particles by the beaters and simultaneously giving them an additional pressure by other means.

(1663) U. S. 1,699,205 (1929). E. Kramer and E. Podszus (Hartstoff-Metall A. G.), *Spherical Metal Particles.* Flake shaped particles are rubbed and rolled in a cylinder which turns over their edges and turns them to spheres.

(1664) U. S. 1,785,283 (1930). E. Podszus (Hartstoff-Metall A. G.), *Metal Powder For Bronze Paint.* The powder is subjected to impacts of a large number of tiny steel balls by imparting to the latter a revolving motion.

(1665) Brit. 341,561 (1931). Hartstoff-Metall A. G., *Production of Sheet-Like Metal Grains.* Method comprises subjecting the particles to a hammering action in a ball mill to form them into small thin foils, conducting a fluid current through the mill whose strength is such that both finished and unfinished particles are carried out of the mill, and separating them outside the mill.

(1666) Brit. 373,784 (1932). Hartstoff-Metall A. G., *Flattening of Metal Powders.* Powder, particularly Al, is subjected to a flattening treatment in an atmosphere of a gaseous mixture of an inert gas with a small amount of an oxidizing gas.

(1667) Brit. 454,750 (1936). Fried. Krupp A. G., *Sintering of Fine Powder.* The structure of the powdered raw material is loosened by submitting it to a stirring or whipping action at a far higher velocity than used in a normal mixing, with addition of moisture, prior to compaction and sintering.

(1668) German 632,776 (1936). F. Skaupy and O. Kantorowicz, *Hardening of Hard Metal Powders.* Hardening of hard metal powders is accomplished by repetition of exerting and releasing a pressure on the powders.

(1669) French 844,187 (1939). B. Bruchard, *Ball-Milling.* The ball-milling of metal powders occurs in several steps and the balls are exchanged for smaller balls after each milling.

(1670) German 678,413 (1939). Siemens & Halske A. G., *Treatment of Iron Powder.* Mechanical working of Fe powder in hammer mills occurs so that a change in form and size of the Fe powder is avoided, and only the hysteresis of the magnetic core later produced of the powder will be diminished.

(1671) U. S. 2,181,123 (1939). J. E. Drapeau, Jr. and L. G. Klinker (Glidden Co.), *Treatment of Metallic Powders.* To improve the degree of compressibility of the material, the powder is subjected to mechanical deformation to set up internal stresses, and heated in a non-oxidizing atmosphere to reduce the internal stresses.

(1672) U. S. 2,244,052 (1941). G. J. Comstock, *Hard Carbide Powder Milling.* A method of reducing metal carbides to sub-colloidal particles of so minute a size, as to stay in suspension in water, is disclosed.

(1673) U. S. 2,306,665 (1942). P. Schwarzkopf (American Electro Metal Corp.), *Method of Preparing Ferritic Iron Powder for Manufacturing Shaped Iron Bodies.* Powdery and porous ferritic iron is subjected at least once to a cycle of treatment comprising mechanically compacting and densifying and comminuting it afterward until briquettable powder of predetermined density and average particle size is obtained.

(1674) Brit. Appl. 34527/47 (1947). D. Primavesi, *Ferromagnetic Metal Powder.* Magnetic powders are coated with softer materials by using an eccentrically mounted ball mill, and placing the powder in a magnetic field and in an inert atmosphere.

(1675) **Brit. Appl. 34530/47** (1947). D. Primavesi, *Manufacture of Homogeneous Powders.* An eccentrically mounted ball mill is claimed to give coated alloyed particles from mixtures such as Fe-graphite, Fe-Pb or Fe-Cu.

(1676) **Brit. Appl. 34532/47** (1947). D. Primavesi, *Material with High Strength at Elevated Temperatures.* Alloy powders mixed in an eccentrically mounted ball mill can be produced with compositions which give control of the properties of the grain boundery.

D. Heat Treating (Drying, Annealing, Degassing)

(1677) **Brit. 173,237** (1923). Westinghouse Lamp Co., *Vacuum-treating Process for the Preparation of Coherent Masses of Rare Metals and Alloys and Oxides Thereof.* Process consists in slowly heating metal powders, *e.g.* 98% W and 2% Th, in a high vacuum to expel all gases before pressing and sintering them.

(1678) **Brit. 291,949** (1928). Ringsdorff Werke A. G., *Drying Powdered Metals.* Drying is accomplished with ethyl alcohol or similar reagents.

(1679) **U. S. 1,669,665** (1928). J. C. Karcher (Western Electric Co.), *Magnetic Material.* Magnetic dust is heat treated prior to insulation and compression, to reach a higher permeability.

(1680) **U. S. 1,674,230** (1928). E. Seyfferth, *Drying And Removing Gases From Powdered Metals.* The powder is pressed into a block, and alcohol is allowed to percolate through the block to remove H_2O present and then to evaporate.

(1681) **U. S. 1,761,016** (1930). R. P. Koehring and C. R. Short (Moraine Products Co.), *Drying Wet Copper Powder.* Drying Cu powder comprises depositing it in a relatively thin layer on a foraminous support, first forcing air heated to approx. 100° C. (212° F.) through the powder for a time insufficient to cause oxidation of the copper, and later progressively decreasing the heated air temperature until the copper powder is dry.

(1682) **U. S. 1,852,583** (1932). J. H. Lucas (Nichols Copper Co.), *Apparatus for Drying or Otherwise Treating Metal Powder.* Drying of metal powders such as Cu is accomplished in inert vapors such as steam.

(1683) **U. S. 1,855,739** (1932). F. Duftschmid and L. Schlecht (I. G. Farbenindustrie A. G.), *Magnetic Iron in Lump Form.* The properties of granular magnetic Fe are made more valuable by a series of heat treatments without sintering.

(1684) **French 767,089** (1934). H. Vogt, *Thermic Treatment of Small Particles.* The particles are treated by moving them in a stream of heating gas which may contain a reducing component.

(1685) **Austrian 140,549** (1935). Fansteel Products Co., *Method of Production of Sintered Hard Alloys.* Each of the powdered alloying constituents of TaC-Ni alloys is heated in vacuo before and after the mixing, to drive off gases and impurities, which may cause porosity and brittleness.

(1686) **U. S. S. R. 51,203** (1937). V. I. Il'gisonis, *Drying Copper Powder.* Cu powder for electric brushes is placed in the wet stage in boxes covered by sheets of Cu, on which is placed a layer of C powder; the boxes are sealed and placed in a drying kiln.

(1687) **Norw. 59,616** (1938). F. Hurum, *Treating Spongy or Powdery Solids With Gases.* Operation is applied to sponge Fe and Fe powder.

(1688) **U. S. 2,186,659** (1940). H. Vogt (Ferrocart Corp.), *Magnetic Powder.* It is produced by cooling and collecting magnetic particles subjected to a reducing gas flame.

(1689) **U. S. 2,200,369** (1940). L. G. Klinker (Johnson Bronze Co.), *Preparing Metallic Powders for Molding.* Powdered metal, *e.g.*, bronze, is mixed with powder or a reducible metal compound, sintered in reducing atmosphere and pulverized. Bronze has oxide-coated particles, but product is suitable for bearings.

(1690) German 704,223 (1941). Metallpulver A. G., *Method for Removing the Milling Lubricant from Aluminum Powder.* It consists of subjecting the powder to a vacuum heating at 380° C. (715° F.) for 3-5 hrs. and cooling in N_2 atmosphere.

(1691) German 705,768 (1941). H. Vogt, *Preparation of Metal Powder.* The conventional metal powder, *e.g.* Fe, is subjected to a special heat treatment prior to pressing and sintering, to form porous, plastic particles of 0.5-1.5 mm. size.

(1692) German 724,105 (1942). Siemens & Halske A. G. and G. Wassermann, *Method of Regulation of Particle Size of Pure Iron.* The cooling down from a temperature within the gamma phase occurs in the presence of H_2 or N_2 which are soluble in Fe, and at a pressure below atmospheric, which is regulated in accordance with the diminution of the particle size.

(1693) Brit. 556,980 (1943). F. W. Berk & Co. Ltd., C. G. Six and W. D. Jones, *Metal Powders.* Process of lowering the apparent density of Cu powder, composed of particles having inside them a reducible oxide of Cu, comprises heating if in a reducing atmosphere at a temperature not being high enough to cause substantial sintering.

(1694) French 881,065 (1943). Deutsche Waffen- und Munitionsfabriken A. G., *Preparation of Iron Powder for Pressing Machine Parts.* Before going to the press, Fe powder is annealed in city gas for conserving the C content during pressing and sintering.

(1695) German 744,048 (1944). Georg Benda-Lutz Werke, *Degreasing Al or Mg Flake Powder.* The powder passes on a conveyer belt over an electrical heater, above which the vaporized grease is removed by suction, and then over a refrigerator.

(1696) U. S. 2,362,302 (1944). G. A. Perry (Carboloy Co.), *Drying Cemented Carbide Compositions.* A pasty carbide mixture is imbedded in NaCl and gradually heated from 40 to 180° C. (105 to 355° F.) in a current of air.

(1697) U. S. 2,375,198 (1945). P. P. Alexander (Metal Hydrides Inc.), *Purification of Calcium.* Method comprises heating the Ca in powder form to a temperature at which the impurities of lower boiling point, but not the calcium, are distilled, followed by selectively oxidizing the resulting metal impurity vapors in a zone removed from the calcium.

(1698) U. S. 2,375,199 (1945). P. P. Alexander (Metal Hydrides Inc.), *Purifying of Metals.* Purifying powdered metals of a higher boiling point contaminated with alkali metal impurities comprises heating the metal to distil the alkali impurities and oxidizing the vapor by bringing it in contact with TiO_2 or ZrO_2.

(1699) U. S. 2,375,200; 2,375,201 (1945). P. P. Alexander (Metal Hydrides Inc.), *Purifying of Barium or Strontium.* Purifying of Ba or Sr powder contaminated with alkali earth impurities by vaporizing the latter and bringing it in contact with TiO_2 or Cr_2O_3.

(1700) U. S. 2,412,145 (1946). G. H. Grene, *Metallurgical Furnace.* An apparatus for heat-treating metal powders or small particles is disclosed.

(1701) U. S. 2,432,856 (1947). P. H. Brace (Westinghouse Electric Corp.), *Method of Purifying Metals.* Method of purifying metals with a melting point over 1000° C. (1830° F.) (such as W or Mo) comprises positioning the metal in an evacuated chamber and heating it, to evacuate the gases, then admitting H_2 containing O_2 and simultaneously heating the metal to a temperature between 70-90% of the melting temperature, and passing the H_2 atmosphere containing reaction products through a labyrinthic collection chamber, to deposit the reaction products.

(1702) Canadian 450,776 (1948). Bell Telephone Labs., W. C. Ellis and A. G. Souden, *Treatment of Finely Divided Magnetic Material.* Fe_3O_4 powder comprising a molecular excess of Fe_2O_3 with respect to FeO is heated to 700° C. (1290° F.) in inert atmosphere for half an hour.

(1703) Brit. 628,183 (1949). The S. K. Wellman Co., *Treatment of Metal Powders.* Finely divided Cu precipitate, after treatment with dilute H_2SO_4 and washing, is subjected to superheated steam for drying and annealing.

(1704) Brit. Appl. 18253/49 (1949). Charles Hardy, Inc., *Annealing or Brightening Oxidized Metal Powder.* The admixture of a small amount of mineral oil to an oxidized metal powder makes it possible to effect reduction in the usual manner without incurring any undesirable agglomeration of the powder, obtained by the very slight teetering effect, produced when the organic material volatilizes.

(1705) U. S. 2,489,116 (1949). J. L. Young (The S. K. Wellman Co.), *Method of Treating Metallic Powders.* Wet powders are passed under exclusion of air in an enclosed vessel, which may be made of a Ni-Cr alloy, through superheated steam at a temperature and for a time sufficient to free the powder of all moisture and to anneal its metal particles. The steam is replaced while still superheated with an atmosphere that is non-oxidizing at all temperatures from that of the superheated steam down to normal room temperature.

E. Cleaning (Polishing, Etching)

(1706) U. S. 1,665,635 (1928). J. W. Marden (Westinghouse Lamp Co.), *Purifying Powdered Metals Such as Thorium and Uranium.* Purification is accomplished by treating the powder with a non-aqueous liquid, such as methyl alcohol, to prevent a further oxidation and combining with the liquid an acid, which will interact with the impurities, to form compounds soluble in the liquid.

(1707) Brit. 341,562 (1931). Hartstoff-Metall A. G., *Apparatus for Polishing Metal Powders Such as Bronze Powders and Coating Them with Grease or Oil.* The apparatus has a cylindrical drum with a brush rotatably mounted to polish the particles which travel from the inlet in one end of the drum to the outlet in the other end.

(1708) U. S. 1,909,586; 1,930,683; 1,930,684 (1933). E. Kramer (Hartstoff Metall A. G., *Polishing Machine.* A polishing machine for bronze colors consists of a drum whose walls are contacted by rotary brushes, having a continuous feed, and an exit system for the powder.

(1709) French 817,774 (1937). H. H. Mandle, *Apparatus for Polishing Metal Powders.* The brushes rotating in the closed cylindric vessel, containing the powder, are regulated from the outside, without opening the vessel.

(1710) Brit. 508,485 (1939). H. H. Mandle, *Apparatus for Polishing Metal Powders.* It produces friction with brushes within a closed cylindrical drum by rotary movement in a gaseous atmosphere.

(1711) U. S. 2,193,663 (1940). F. C. Arthur (Aluminum Co. of America), *Polishing Metal Powder.* Dry metal powder is polished in a cylindrical drum by a series of rotating brushes.

(1712) U. S. 2,199,707 (1940). H. H. Mandle (United States Metal Powders Inc.), *Machine for Polishing Metal Powders.* Machine comprises a closed cylindrical drum, several sets of brushes, and means for rotation and control.

(1713) U. S. 2,218,852 (1940). H. H. Mandle (United States Metal Powders Inc.), *Dispensing Device for Polishing Drums for Powders.* The device consists of a rotary disk mounted with its upper surface lying in the bottom of the container, and disposed partly within the container, to move the apertures in the disk successively from within the chamber to the discharge station.

(1714) Brit. 558,107 (1943). E. I. Du Pont de Nemours & Co., *Metallic Powders.* Lamellar Cu or Cu-alloy powders having high brilliance are produced by polishing the powder in the presence of a small amount of a partially polymerized urea CH_2O resin.

(1715) Brit. 606,751 (1948). Metals Disintegrating Co., Inc., *Increasing Specular Reflectivity of Metal Flakes.* A standard filter cake of 80% Al or 90% Cu of a leafing powder is extruded under such conditions that the particles are polished, burnished and flattened, thus giving improvement in metallic lustre; aggregates are broken up, to increase reflectivity.

(1716) **U. S. 2,436,772** (1948). W. Klabunde (E. I. du Pont de Nemours & Co.), *Solvent for Degreasing Iron or Aluminum Powder.* Containing trichlorethylene with 0.02-1% alkyl ester of a N-acid, to inhibit the condensation reaction of trichlorethylene catalyzed by the metals.

F. Conveying (Feeding)

(1717) **Italian 396,114** (1942). P. Golfetto, *Discharge and Feeding Arrangement for Powder Products.* Balling up and bridging of certain powders is prevented by a special hopper equipped with a blade or drum mixer.

(1718) **U. S. 2,301,084** (1942). A. De Los Sinden, *Conveyor.* The conveyor claimed is particularly adapted for handling fine powdered metal.

(1719) **U. S. 2,389,566** (1945). P. E. Thomas (Republic Steel Corp.), *Solids Feeder.* Apparatus for controlling the feed of fine solids in a sintering machine is claimed.

(1720) **French 912,167; 912,168** (1946). S. A. Metallurgie Du Nickel, *Machine for Filling Tubes with Metal Powders.* Machine is suitable for making resistor bars in which the powder is packed to uniform density by electro-magnetic vibration during filling.

(1721) **U. S. 2,422,470** (1947). M. L. Cover (National Steel Corp.), *Swinging Spout for Sintering Machines.* A spout for delivering granular material to the traveling bed comprising a swinging box above the bed, a deflector plate between side walls and sloping downward toward the front wall, and a curtain at the rear wall.

(1722) **U. S. 2,477,414** (1949). G. I. McBride (The Permanente Metals Corp.), *Pneumatic Dust Conveyer.* The apparatus comprises a vertical system which makes it possible to take advantage of the forces of gravity in feeding metallic or nonmetallic dust to a jet of inert gas into a system of pipes leading to the desired point; the same system may be operated satisfactorily in a horizontal arrangement.

2. MOLDING, PRESSING AND BRIQUETTING

A. Cold Static Pressing of Ingots and Briquettes (including hydrostatic pressing)

(1723) **U. S. 778,899** (1905). A. Ronay, *Forming Blocks of Ore.* The ore powder or granules are pressed with increasing pressure until 800 kg/cm.^{2} (6 tsi) is reached.

(1724) **U. S. 943,724** (1909). L. Weiss, *Process of Briquetting Iron.* It consists of mixing powdered or granulated Fe with carbonaceous material and lime water and pressing the mixture.

(1725) **U. S. 958,700; 958,701** (1910). M. Glass, *Process of Briquetting Fines of Ore.* It comprises mixing the ore with a solution of water-glass, a Ca compound and quicklime, and pressing the mixture.

(1726) **Brit. 28,829/1909** (1911). M. Glass, *Improved Process for Briquetting Fine Ore and Other Materials.* Pressing of powdered Fe-ore or other material with binding agent is claimed.

(1727) **U. S. 1,008,254** (1911). M. Glass, *Process of Briquetting Metals Containing Copper.* Cupriferous metals are briquetted by treating them with a solution of ammonium compound in the presence of Cu-oxide, pressing and subsequently heating by means of slaking of the admixed quicklime.

(1728) U. S. 1,081,618 (1913). H. D. Madden (Westinghouse Lamp Co.), *Process of Preparing Billets of Refractory Materials.* Manufacture of coherent metallic billets for tubings etc. of refractory material comprises subjecting the bodies of powdered material to a high pressure uniformly exerted thereon in all directions with the aid of two coaxial rubber tubes.

(1729) U. S. 1,174,646 (1916). J. A. Williams, *Method of Producing Solid Bodies from Metal Powders.* Solid metal bodies are formed from W and other metals in finely divided form by withdrawing air from them and subjecting them to pressure.

(1730) Brit. 103,553 (1917). E. R. Sutcliffe and T. G. Hirst, *Improvements Relating to the Treatment of Metal Scrap.* Metal scrap mixed with flux is pressed into bars which are then melted down.

(1731) Brit. 113,836 (1918). M. J. Insull, *Compressing of Tungsten Powder.* The method comprises applying a high pressure, greater than 130 tsi to the powder, and then relieving the pressure therefrom so as to permit the body to expand in all directions.

(1732) French 485,552 (1918). M. J. Insull, *Pressed Tungsten Powder.* The powder is pressed in a mold whose side jaws are lifted after pressing at 20 tons/cm^2. (140 tsi) to produce an ingot bar of a density of 17.25 g./cm.^{3}.

(1733) U. S. 1,299,878 (1919). F. A. Vogel, *Metal Briquette.* By subjecting the turnings or borings, obtained by a size-reducing crushing, to annealing, briquetting is facilitated at low pressures.

(1734) U. S. 1,305,975 (1919). C. A. Pfanstiehl (Pfanstiehl Co.), *Method of Compressing Tungsten Powder.* It consists of compressing W-powder ingots and then relieving the pressure to permit the powder mass to expand equally in all directions.

(1735) U. S. 1,321,125 (1919). C. A. Pfanstiehl (Pfanstiehl Co.), *Method of Compressing Powdered Metal such as Tungsten.* W and like metals are compressed by placing the powder between a metallic cup and a die, subjecting the interior of the cup to fluid pressure, expanding, and thus compressing the powder.

(1736) German 363,226 (1922). Pfanstiehl Co., *Method of Producing Briquettes.* The method of producing briquettes from powdered W employs a pressure of 9,000-20,000 kg./cm^2. (64–142 tsi).

(1737) Swiss 97,278 (1922). Licht A. G., *Production of Pressings from Refractory Metals.* The metal powders are pressed between the parts of the die which have cylindrical recesses in such a manner that at the finish of the pressing action no part of the die embraces the pressing on half of its circumference.

(1738) Austrian 94,643 (1923). Pfanstiehl Co., Inc., *Pressing of Tungsten Powder to Dense Bodies.* The pressure is increased to 20 tons/cm.^{2} (140 tsi) and the side walls of the mold are moved outside after diminishing the pressure.

(1739) U. S. 1,510,745 (1924). A. B. Montgomery, *Briquette of Metal Particles.* A briquette having a highly compacted central structure and more highly compacted outer portion is produced by using plungers of different length acting on the material added and compacted in several steps.

(1740) French 702,077 (1931). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Molding Compositions.* Molding of powders into briquettes of refractory metals comprises the use of a binding agent and water.

(1741) Swiss 159,202 (1933). Wolfram & Molybdän A. G., *Method for the Production of Hard Metal Bodies.* The briquette is pressed with elastic interpositions on all sides of the form, then shaped by working, and sintered, without presintering. Pressing operation involves compaction by means of a rubber hose that is surrounded by a liquid medium such as water.

(1742) French 762,072 (1934). Aubert & Duval Frères, *Pressing of Hard Metal Powders.* The pressing of a mixture of 80% TaC, 10% W and 10% Ni takes place at 20,000-30,000 kg/cm.^{2} (140-210 tsi).

(1743) Japan. 113,826 (1935). T. Kamaya, *Method of Briquetting Powdered Iron.* A mixture of 10-30% powdered Fe, $CaCN_2$ residue, and a small amount of water is pressed into blocks which are charged into a cupola furnace with coke and heated.

(1744) U. S. 2,111,344 (1938). J. W. Weitzenkorn (Ohio Ferro Alloys Corp.), *Metallurgical Briquette.* Metallic briquettes are made by utilizing as a binder a metalliferous product which is of value in the manufacture of Fe and steel.

(1745) U. S. 2,127,994 (1938). J. H. Davis and J. C. Lemming (General Motors Corp.), *Method of Briquetting Finely Divided Material.* Briquetting loose powdered material, such as metals and graphite, comprises dropping the loose powder into a cavity which is formed by the receding movement of the bottom, forming a ram, and then moving the ram upward to compact the powder.

(1746) Brit. 517,994 (1940). Magnesium Metal Corp. Ltd., *Magnesium Dust Briquettes.* Process for production of briquettes from Mg dust accruing in electro-thermal production of Mg from MgO with C by briquetting under high pressure without binder.

(1747) Swiss 208,390 (1940). Climax Molybdenum Co., *Briquette for Production of Molybdenum-Iron Alloy.* Roasted Mo glance is mixed with a binder and pressed to briquettes, having a high specific gravity.

(1748) French 866,945 (1941). L. Renault, *Method of Agglomeration of Sintered Metals.* The molding pressure is exerted between 10,000 and 20,000 kg./cm.^{2} (70-140 tsi) on the mold with a conical and rotating stem.

(1749) German 723,387 (1942). H. Vogt, *Procedure for Pressing Hard Metals.* A method of producing hard metal bodies from powders having a high inner friction, imparts to the powder compact in the mold an equal density before pressing and sintering, by arranging plates of rubber between punches and the powder compact.

(1750) U. S. 2,311,940 (1943). B. Grob and R. Zaun, *Briquetting Machine.* In a machine for forming solid briquettes from cast Fe chips, the briquettes are given a "skin" to protect the center portion of the briquette from oxidation during subsequent melting.

(1751) U. S. 2,341,732 (1944). J. T. Marvin (General Motors Corp.), *Method and Apparatus for Briquetting of Powdered Metals.* Method and press are disclosed for the forming of a long length of porous metallic strips made of different layers of metals subsequently consolidated by sintering.

(1752) French 950,169 (1949). Stora Kopparbergs Bergslags A. B., *Manufacture of Powder Metallurgy Products, Especially from Hard Metal Carbides.* The powders are pressed in graphite dies, which in turn are produced by compaction of graphite powder at about 25 tsi. The die wall friction is so markedly reduced that the carbide powder requires a compacting pressure of only 700-1400 psi to give the same ultimate product as obtained by pressing in steel dies at 6 tsi. The carbide powder is preferably moistened with alcohol. The use of steatite dies is also claimed.

B. Cold Static Pressing of Parts (including insert molding)

(1753) German 460,000 (1928). Bound Brook Oil-Less Bearing Co., *Producing Tubes of Powdered Metal.* Method of producing tubes of powdered metals comprises filling a coreless shape with powders, pressing into the mass a core for producing a tubular form, then compressing the material by punches, and heating the compressed tube.

(1754) German 469,805 (1928). Bound Brook Oil-Less Bearing Co., *Production of Porous Bearings.* Bearings, produced from powders, with parts of different thickness in the pressing direction, are made by means of press rams which are flexibly movable in the pressing direction, to produce a uniform density.

(1755) U. S. 1,959,422 (1934). R. A. Harris (Western Electric Co.), *Method of Forming A Die Mounting.* It consists of centering die cores in a mass of powdered Ni and Fe, pressing, and sintering.

(1756) U. S. 2,195,749 (1940). J. A. Lignian (General Motors Corp.), *Method of Making Bearing.* Annular oil recesses in bushings are formed by briquetting and sintering a mixture of metal powders.

(1757) U. S. 2,259,094 (1941) S. K. Wellman (S. K. Wellman Co.), *Method of Making Bodies of Pressed Metal Powders.* The expansion of a compressed body, such as a bearing, can be delayed after the body is removed from the walls of the mold by applying a pressure to the portions of the body which lie adjacent to the opposing walls of the mold.

(1758) U. S. 2,275,592 (1942). H. Menihan (American Bank Note Co.), *Method of Making Printed Articles.* It consists of compressing powdered material against an engraved and inked printing element until the powder forms a self-sustaining printed solid.

(1759) U. S. 2,289,787 (1942). K. Kaschke and H. Vogt, *Production of Shaped Articles from Metal Powder.* A porous Fe rod is produced by successively compressing portions of porous metal powder against an already compressed portion of the same powder in a die and sintering.

(1760) U. S. 2,298,885 (1942). A. W. Hull (General Electric Co.), *Method for Producing High Density Sintered Iron Products.* A body of complex shape and uniform density, *e. g.* turbine bucket, is produced from powdered ingredients by pressing in a rigid mold with a rigid plunger and a flexible pad.

(1761) U. S. 2,331,909 (1943). F. R. Hensel (P. R. Mallory and Co.), *Gear and the Like.* A method of producing toothed parts, such as gears, sprocket wheels and racks, by molding metal powders is claimed.

(1762) U. S. 2,357,407 (1944). L. Kurtz (General Motors Corp.), *Method of Molding an Article of Powdered Material.* Molding article of complicated shape comprises filling the mold from the smaller diameter end and compressing the powder from opposed axial directions, then ejecting the product from the larger diameter end.

(1763) U. S. 2,386,604 (1945). C. G. Goetzel (American Electro Metal Corp.), *Method of Molding Under Pressure Metallic Powders.* Method of making complicated curved shapes comprises forming intermediate shapes of densities halfway between the apparent density of the powder and the final density of the finished part.

(1764) Brit. Appl. 14176/47 (1947). Mallory Metallurgical Products Ltd., *Pressing Objects from Metal Powders.* Needle tips or pen points can be mass-produced by using a die plate with multiple cavities (*e.g.* 21) and placing Cu slugs over the filled cavities and exerting a pressure. The die cavities are coated with a lubricant (1-5% paraffin in CCl_4). A composition of 50% Os, 34% WC and 16% Co is preferred; it is pressed at 50-100 tsi. and sintered at 1450° C. (2640° F.).

(1765) Brit. 598,423 (1948). American Electro Metal Corp., *Method of Compacting Metal Powders.* Parts having undercuts or recesses are made by feeding the powder into a split die around a loosely fitting upper punch. The powder is successively compacted. A rubber bag is then inserted into the cavity left by the punch and is inflated by compressed air, which exerts lateral pressure upon the powder.

(1766) U. S. 2,447,434 (1948). P. Schwarzkopf (American Electro Metal Corp.), *Compacting Metal Powder into Complicated Shape.* In the first step a cored compact is preformed by pressing in the direction coaxial with the core, while in the second step the preformed cored part is compacted laterally by pressure applied to the walls of the hole; pressure means are tubes of rubber, expanded by compressed air or liquid.

(1767) U. S. 2,449,515 (1948). R. P. Seelig (Reconstruction Finance Corp.), *Pressing Parts from Powder.* During the ejection from the die cavity the part is maintained under a yielding diminishing pressure; parts of intricate design have uniform density.

(1768) U. S. 2,479,364 (1949). D. L. Jocelyn, *Method of Making Molds.* A powdered metal mold may be made, using a forming punch contoured with different levels, by supporting a loose mass of powdered metal in a confined space opposite the punch, placing pre-compressed powdered metal briquettes of

different thicknesses in the mass opposite the different lower levels of the punch, and consolidating the mass into briquettes by pressure of the punch.

(1769) U. S. 2,481,232 (1949). N. C. Moore (The Plessey Co., Ltd.), *Powder Metallurgy.* Method consists in the production of a compact by the application of pressure which is reduced first in one plane and then at right angles to that plane. The pressure is first reduced to a fraction and finally to a minute portion of the original. The process is carried out by means of a mold in which independent pressures and reductions thereof can be applied at the top and bottom or on all sides either separately or in combination. A primary feature of the invention is the use of powder, free from any lubricant.

C. Dynamic Pressing and Molding (including centrifugal pressing)

(1770) Brit. 401,521 (1933). Wolfram & Molybdän A. G., *Pressed Shaped Pieces of Hard Metals.* Pressing, without preliminary sintering, is carried out with positive dynamic pressure on all sides and the shaping of the pressed pieces into commodities is immediately effected.

(1771) German 570,813 (1933). W. Müller, *Compression of Sintering Bodies.* The mixture of refractory metal carbide powder and binder metal powder is loaded with an auxiliary fused metal into the vessel of a centrifuge, so that a pressure is exerted on the mixture during heating and centrifuging.

(1772) French 819,838 (1937). P. Brun, *Agglomerating and Fritting Metal Powders.* Powders contained in molds specially adapted are subjected to action of centrifugal force which rapidly creates a perfect equilibrium of pressures.

(1773) Belgian 439,735 (1940). Aktiebolaget Hammarbylampan, *Production of Sintered Bodies.* A graphite mold, containing the metal powders, is rotated very quickly to compress the powder, and the compact is then sintered.

(1774) U. S. 2,198,612 (1940). C. Hardy (Hardy Metallurgical Co.), *Powder Metallurgy.* Process involves evacuating of powders during cold pressing of parts and removal of air prior to molding while vibrating the powder.

(1775) Australian 113,396 (1941). Aktiebolaget Hammarlampan, *Centrifugal Molding of Articles of Sintered Hard Alloys.* Production of shaped articles of sintered metals or hard alloys comprises introducing a powder into a mold in which the mixture is subjected to a centrifuging or throwing action, *e.g.* by moving the mold in a circular path, to shape the mixture into a compressed body and then sintering it.

(1776) German 704,463 (1941). Fried. Krupp A. G., W. Dawihl and H. Franssen, *Production of Sintered Hard Metals.* The powders are agitated in the mixing vessel or in the pressing mold while subjected to ultra-sonic vibrations.

(1777) Swedish 104,196 (1942). A. B. Hammarbylampan, H. A. M. Larsson, and H. H. Wolff, *Process for Manufacture of Objects of Sintered Alloys.* The process, especially suitable for hard alloys, is characterized by filling a die with a mixture of the finely divided components of the alloy, and compacting it into a condensed body through centrifuging or moving the die in a preferrably circular path, whereafter sintering is effected.

(1778) Swedish 105,213 (1942). Aktiebolaget Hammarbylampan, and C. Axberg, *Process for Compacting and Sintering of Objects of Metal or Hard Alloy.* Process for forming and sintering of objects of metal or hard alloy from a mixture of components making up the objects, is characterized by a transfer of the components to and compacting in a die of suitable design where they are sintered with the application of heat; the components are worked by forces of acceleration both during compacting and sintering, the object being centrifuged.

(1779) Swedish 106,180 (1942). Aktiebolaget Hammarbylampan, *Process for Sintered-Alloy Compacts.* Supplement to Swedish 104,196 (No. 1777). Plunger consists of several parts which insure even distribution of pressure on the powder mass during centrifuging even if the surface of the compact is irregular or complex.

(1780) Swedish 106,696 (1942). Aktiebolaget Hammarbylampan, *Process for Manufacture of Objects of Sintered Alloys.* Supplement to Swedish Pat. 104,196 (No. 1777). Describes process according to which the components are subjected to vibrations during the centrifuging.

(1781) Swiss 221,356 (1942). Aktiebolaget Hammarbylampan, *Method for Production of Bodies of Hard Alloys.* The powdered mixture is pressed into a form by centrifuging and then the body is sintered.

(1782) U. S. 2,304,723 (1942). H. A. M. Larsson and H. H. Wolff, *Process for the Manufacture of Articles of Sintered Metallic Constituents.* Centrifugal cold pressing of sintered shaped bodies in graphite dies and rotation of the mold are claimed.

(1783) German 736,323 (1943). J. R. Rietveld, *Production of Drawing Dies.* The metal carbide powders in form of a paste or a suspension in a viscous fluid are compressed by centrifugal action into the desired form. The powder is distributed in the slurry in such way that the finest fraction is charged to the center portion.

(1784) Swedish 108,681 (1943). Lumalampan A. B., *Sintered Metal Body.* Produced from W or Mo, or their carbides, nitrides, silicide or borides in such a way that the mixture of the carbide, nitride, silicide or boride is changed continuously in one direction of the body; this is accomplished by centrifugal action on the powder in the mold.

(1785) Swedish 108,993 (1943). Sandvikens Jernverks A. B., *Method for Production of Powder Mixtures and Compacts.* Application of supersonic vibrations is resorted to for good mixing of the powder and dispersion of the powder particle sizes in the pressing mold.

(1786) U. S. 2,311,940 (1943). B. Grob (Robert Zaun), *Briquetting Machine.* A machine of percussion blow type with movable means providing a series of apertures for the material, and indexing means for the successive movement of the apertures to receive the tool during the percussion blows, is disclosed for the briquetting of powders.

(1787) Brit. 562,934 (1944). General Motors Corp., R. G. Olt and E. W. Reinsch, *Porous Metal Plates.* In the molding of metal powders in a non-compacted condition, centrifugal force is utilized to fill an enclosed mold cavity.

(1788) Brit. 580,490 (1944). British Thomson-Houston Co. Ltd., *Consolidation by Vibratory Compaction.* Vibration of a filled die without rotation by means of a 60-cycle alternating current passing through a solenoid is claimed to be equivalent to the usual methods of cold pressing.

(1789) German 745,875; 745,876 (1944). W. Jaeger, *Manufacture of Steel-Backed Bearings.* A vertically adjustable C-base plate carries the bush inside a shaped C-sleeve with a cone-topped C-cylinder arranged inside the bush for distributing the bearing surface powder. The powder in the gap between the bush and the inside cylinder is tamped by another cylinder subjected to 3000 vibrations per min., and the base itself can be vibrated by means of eccentrics.

(1790) U. S. 2,379,540 (1945). A. W. Morris, *Method and Apparatus for Making Metal Articles from Metal Powder.* Pressing is accomplished by dynamic blows of a hammer having a specific toothed form; the face of the hammer is formed like an end milling cutter, but so that the twist of the ram as it hits the powder is in a direction opposite to that of a cutter.

(1791) U. S. 2,435,227 (1948). H. H. Lester (U.S.A. as represented by Secretary of War), *Method for Producing Articles from Powdered Materials.* It consists of placing powdered materials in a mold, and vibrating and simultaneously rotating the material about an axis normal to the direction of vibrating to compact the powder; a coherent solid article is formed by sintering.

D. Wet Pressing and Molding

(1792) German 180,648 (1907). Küppers Metallwerke A. G., *Method of Producing Metal Parts.* Method of producing metal parts comprises spraying the molten metal and mixing the particles with a non-metallic powder and with a small quantity of diluted acid, to make a paste which then is poured out into a mold.

(1793) Brit. 24,631/1909 (1910). E. Sanna, *Compacting of Wet Spongy Zinc.* Process for transforming spongy Zn into compact marketable pieces consists in heating the sponge in a wet state and subjecting it to a strong pressure.

(1794) Brit. 12,535/1910 (1911). E. Weber, *Castable Masses Produced from Powdered Non-Plastic Substances.* Non-plastic substances such as quartz, carborundum, magnesite, ZnO, S, graphite, and powdered metals can be rendered castable if mixed with a little water and alkali, and cast in water-absorbing molds.

(1795) U. S. 2,001,134 (1935). C. Hardy (Hardy Metallurgical Co.), *Compression.* Compression of the metal powders with soap water or other liquid binder followed by sintering is claimed.

(1796) Brit. 441,177 (1936). Hardy Metallurgical Co., *Production of Metallic Articles.* Method comprises the compressing of metal powders deposited from solution while they are still wet, to form a coherent mass, which is sintered.

(1797) German 627,980 (1936). Siemens & Halske A. G., *Sintered Bodies from Hard Metals.* Sintered bodies from hard metals containing carbides, borides or nitrides comprises adding an electrolyte to permit pouring, then casting the mass cold in an absorbent mold, drying the product and sintering it.

(1798) U. S. 2,027,532 (1936). C. Hardy (Hardy Metallurgical Co.), *Forming Powder Metallurgy Articles From Plated Metal Powders by Wet-Pressing.* Method consists of compressing the wet, plated powders into a coherent mass with water, and heating before the original soft amorphous character of the plating has been altered, thereby reducing the compressive force to form a coherent mass of predetermined density.

(1799) French 889,433 (1943). H. Vogt, *Production of Magnetic Pieces with Threads.* Moist powder is mixed with lacquer and pressed in a form having a threaded mandrel which can be turned out after the operation.

E. Pressing by Metal Working (Rolling, Hammering)

(1800) U. S. 936,403 (1909). W. v. Bolton (Siemens & Halske A. G.), *Production of Filaments.* Filaments are produced by inserting refractory metal powder into a tube of ductile metal, and working the tube and the metal powder into filament form.

(1801) U. S. 1,930,287 (1933). C. R. Short and C. V. Morton (Moraine Products Co.), *Method of Making Porous Metal Bodies.* Method of making porous metal bodies having a laminated structure of different porosity comprises rolling powdered material while on a conveyer to carry the material between rollers to form a strip of the desired thickness and density, and sintering the formed sheet.

(1802) Swedish 86,902 (1936). H. Unckel, *Alloys of Metal Powders.* Metal powders are placed in a metal tube and hermetically sealed; the tube is then rolled and drawn and heated to sintering temperature.

(1803) Swedish 87,399 (1936). Finspongs Metallverks A. B., *Sintering of Metal Powders.* Metal carbide powders are filled into an iron tube, sealed hermetically, and the tube is then drawn or rolled and the powder mass sintered.

(1804) U. S. 2,134,366 (1938). C. Hardy (Hardy Metallurgical Co.), *Metal Sheet Manufacture from Metal Powders, e. g. Copper.* Method comprises producing metal sheets by feeding the metal powder onto a rotating endless smooth metallic surface and exerting pressure between rolls on the powder, and passing the sur-

face through a heating zone, to cause further consolidation of the sheet.

(1805) U. S. 2,178,529 (1939). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Pressing of Porous Sheet Metal for Bearings.* A mixture including powdered metals having different melting points, such as one containing Cu, Sn, Pb, boric acid and graphite, is continuously fed directly between opposed arcuate surfaces of a pair of pressure rolls to compress the mixture uniformly from opposite sides into a sheet-like briquette form, followed by heating to a sintering temperature in a furnace having a non-oxidizing atmosphere.

(1806) Brit. 528,370 (1940). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Porous Bearing Sheets. Cf:* U. S. 2,178,529 (No. 1805).

(1807) U. S. 2,218,809 (1940). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Porous Metal Forming Apparatus.* The apparatus for making sheet porous metal in a continuous strip includes a pair of horizontally disposed laterally spaced pressure rolls, means for feeding a mixture of powdered constituents vertically downwards directly between the rolls, a mechanism for driving the rolls to compress the mixture uniformly from opposite sides, and a sintering furnace.

(1808) French 884,183 (1943). Metallgesellschaft A. G., *Method of Rolling Metal Powders.* The powder is filled in a tube which is used as cover during the compression by rolling or drawing.

(1809) Swiss 227,631 (1943). Metallgesellschaft A. G., *Compound Body.* Metal powder is filled into a tube which is worked in an extrusion press.

(1810) French 922,263 (1947). R. Lacroix, *Compacting of Metal Powders by Hammering.* Depending on the profiles of hammer and die it is possible to obtain green pressings in form of ribbon, rod or tubing. The process can also be operated as a powder coating method.

F. Presses, Dies, Molds, Attachments and Lubrication

(1811) U. S. 610,029 (1898). E. C. Clark, *Powder Press for Tablets.* It comprises a rotary table with pockets, a stationary feed-frame, and plungers and dies carried by the table.

(1812) Brit. 12,244/1912 (1913). C. Gladitz, *Press for Compacting Refractory Metal Powders.* A press mold for manufacturing of pressed bars of W or Pt from powder has a loose member adapted to have external pressure applied to it, and a release of the bar in one direction; the mold is adapted to allow the release of the bar in two other directions.

(1813) U. S. 1,091,430 (1914). K. Gladitz, *Press Mold.* The mold has a body with a recess wider at one end than at the other having a lining plate at its bottom and two lateral plates, between which a plunger operates, and means for release of the lateral pressure in the mold after the pressing.

(1814) U. S. 1,099,667 (1914). A. Ronay, *Press.* It has a feed chamber for powdered material and stamps movable in the walls of the chamber, the inner ends of the stamps forming a mold.

(1815) U. S. 1,166,558 (1916). F. E. Stevenson and H. C. Little, *Press.* A press is designed to compress salt into blocks with a floating spring-supported mold.

(1816) U. S. 1,181,199 (1916). E. B. A. Zwoyer, *Press.* It has a pair of pocketed rolls which rotate in the same direction to bring the pockets into coincidence and effect pressing of powdered material.

(1817) U. S. 1,207,337 (1916). F. J. Stokes, *Rotary Press for Tablets.* It has a punch consisting of a single piece perforated in its length and provided between its ends with a radial slot communicating with the perforation.

(1818) U. S. 1,220,733 (1917). O. C. Duryea (American Briquette Machine Co.), *Briquetting Press.* It has a tubular die and a movable anvil closing one end of

the die and a plunger mounted to travel in and out of the opposite end of the die.

(1819) U. S. 1,247,667 (1917). T. Gilmore (General Briquetting Co.), *Briquetting Machine.* The machine operates entirely in the horizontal direction and is thus capable of producing briquettes of maximum quality while working at low tonnage capacity.

(1820) U. S. 1,265,441 (1918). E. Fernholtz, *Briquetting Machine.* It has means of producing a briquette in the mold under full pressure and means to discharge the briquette under reduced pressure.

(1821) U. S. 1,295,764 (1919). G. Komarek (St. Louis Briquette Machine Co.), *Briquetting Machine.* It has a pair of pressure drums provided in their peripheries with rows of mold cavities.

(1822) U. S. 1,322,960 (1919). W. Schumacher (General Briquetting Co.), *Briquetting Press.* In combination with a resiliently mounted die, a mold is arranged to slide in the direction in which the pressure is exerted upon the material.

(1823) U. S. 1,326,614 (1919). C. A. Pfanstiehl (Pfanstiehl Co.), *Machine for Compressing Tungsten-Powder or Other Similar Materials.* A die allowing for expansion of the compressed material vertically as well as laterally is claimed.

(1824) U. S. 1,332,983 (1920). T. Gilmore, *Briquetting Machine.* It consists of pressure means and a mold, an accumulator, an intensifier and controlling means.

(1825) French 524,607 (1921). A. Guéret, *Press for Powders.* It has several pistons which exercise vibrations to heated powder during the compression.

(1826) U. S. 1,368,942 (1921). G. Komarek (St. Louis Briquette Machine Co.), *Chain for Briquetting Machines.* A chain applied to one of the forming rolls constitutes an end wall for the mold cavities in the rolls.

(1827) U. S. 1,607,389 (1926). C. Claus (Bound Brook Oil-Less Bearing Co.), *Machine for Pressing Metal Articles.* It has a mold chamber, a movable core-forming mandrel, and means for moving the mandrel longitudinally to dispose of the loose, granular powder in an annular mass.

(1828) U. S. 1,609,460 (1926). W. S. Buttles (Western Electric Co.), *Molding Apparatus.* Two forming members are disposed within an annular die, which is composed of separable segments, removably seated in a tapered aperture.

(1829) U. S. 1,624,904 (1927). C. Claus (Bound Brook Oil-Less Bearing Co.), *Method and Apparatus for Forming Bodies by Pressure.* Method consists of employing die members of which a recess has a yielding capacity in the direction of the compressing force.

(1830) U. S. 1,648,721; 1,648,722 (1927). C. Claus (Bound Brook Oil-Less Bearing Co.), *Machine for Forming Bodies by Pressure.* Device for powder-pressing makes bodies of varying thicknesses or dimensions in the direction of pressure application by compressing a charge of material in the direction of the varying thickness or dimensions, and causing the compression of the thicker dimension to be exerted from opposite directions thereon, while the compression of the thinner dimensions is effected by yielding compression.

(1831) U. S. 1,679,408 (1928). J. H. Davis and A. H. Valentine (Moraine Products Co.), *Briquetting Apparatus.* Apparatus for molding mixtures of powdered metal and graphite in the manufacture of porous bearings is disclosed.

(1832) U. S. 1,766,265 (1930). F. H. Smith and A. K. Nowak, *Press.* The mold chamber and the core member are yieldably supported to have a movement in the direction of the pressure exerting plunger.

(1833) U. S. 1,768,500 (1930). L. H. Bailey (F. J. Stokes Machine Co.), *Compressing Machine.* An automatic press moving simultaneously the upper and lower punch is disclosed.

(1834) U. S. 1,775,701 (1930). W. H. Smith, *Metallic Mold and Process for Forming The Same.* The mold has walls of pressed and sintered Fe powder plus a metallic oxide.

(1835) U. S. 1,806,300 (1931). J. C. Lemming (Moraine Products Co.), *Briquetting Machine.* Method of and machine for forming hollow bushings, or other apertured articles from powdered materials are claimed.

(1836) U. S. 1,820,235 (1931). J.C. Lemming and A.H. Valentine (Moraine Products Co.). *Briquetting Machine.* An apparatus is disclosed for highly compressing metal powder or other finely divided material into bushings having portions of different diameters.

(1837) U. S. 1,844,700 (1932). F. J. Stokes, *Rotary Tablet or Briquetting Machine.* A rotary head with dies, top and bottom punches, top and bottom rolls for the punches, and means for adjusting them, are disclosed.

(1838) U. S. 1,855,855 (1932). R. Gillis and J. C. Morison (Western Electric Co.), *Molding Die.* The die consists of a base member having walls forming a circular recess and a plurality of curved sections forming a ring to receive the material to be molded.

(1839) U. S. 1,940,294 (1933). W. G. Calkins (Chrysler Corp.), *Die.* A die part includes a compressed mass of sponge Fe particles having a large degree of porosity, particles of Cu fused to Fe, and a lubricant (graphite).

(1840) U. S. 1,974,214 (1934). R. W. Glasner and F. J. Rode (Marquette Tool and Mfg. Co.), *Machine for Manufacturing Bushings.* A machine for compressing metal powder consists of a pressing chamber, a chute with movable discharging end, and means for ejecting the product from the chamber into a position out of the way of the chute, when the latter delivers material into the chamber.

(1841) U. S. 2,043,085 (1936). C. J. Westin and C. J. Beck (F. J. Stokes Machine Co.), *Tablet Machine.* A rotary press with improved ejecting device is disclosed.

(1842) U. S. 2,043,086 (1936). C. J. Westin and A. Donaghy, Sr. (F. J. Stokes Co.), *Tablet Compressing Machine.* A multi-punch press with rotating mold table is disclosed.

(1843) U. S. 2,044,556 (1936). G. W. Woods (Hughes Tool Co.), *Device for Applying Tungsten-Carbide to Tool Blades.* Structural and operative details for a vibrating container and spout device are disclosed.

(1844) U. S. 2,068,619 (1937). L. H. Bailey (F. J. Stokes Machine Co.), *Tablet Making Machine.* A rotary press for tablets with irregular shaped perforations is disclosed.

(1845) U. S. 2,109,407 (1938). C. J. Westin (F. J. Stokes Machine Co.), *Tablet Packaging Machine.* A press with packaging and counting device for tablets is disclosed.

(1846) U. S. 2,118,205 (1938). K. Klöne, *Apparatus for Briquetting Metal Shavings, Particularly Woolly, Tenacious Shavings.* It has means for feeding the shavings from a delivery station to a cutting device including two knives, one movable toward the other, and carriers to forming dies for compressing the shavings.

(1847) U. S. 2,168,075 (1939). F. J. Stokes (F. J. Stokes Machine Co.), *Compressing Machine.* A tablet press with a pair of co-operating punches is disclosed.

(1848) U. S. 2,169,281 (1939). C.A. Pfanstiehl (Pfanstiehl Chemical Co.), *Apparatus for Forming Shaped Small Objects.* The cavities in the die, having the same shape as the finished article, are larger than the article itself, because of a change in apparent density of the article which occurs upon compression.

(1849) Brit. 529,578 (1940). Johnson Laboratories and A. D. Whipple, *Means for Compressing Finely Divided Substances.* An apparatus for compressing finely divided substances such as Fe powder, provides for an axial movement of the mold during the compression operation.

(1850) Brit. 538,803 (1941). S. K. Wellman Co., *Spreading Powdered Material in a Mold.* Layer formation during pressing and sintering is accomplished by a special feeding device.

(1851) German 710,881 (1941). H. Luce (Rheinmetall-Borsig A. G.), *Pressing Tool.* It has punches of different length which rest upon a deformable mass such as wax.

(1852) German 716,118 (1941). H. Apfelbeck, *Feeder for Conveying Powdered Materials Into a Press.* Within the feeder a stirrer built in a cage of wire or rods is arranged.

(1853) U. S. 2,240,971 (1941). S. K. Wellman (S. K. Wellman Co.), *Method and Apparatus for Spreading Powdered Material.* A device is claimed for the spreading of metal powders in layers in a mold, with the powder subsequently being pressed, sintered or hot-pressed.

(1854) U. S. 2,253,003 (1941). A. D. Whipple (Johnson Laboratories), *Means for Compressing Finely Divided Substances.* In an apparatus for compressing finely divided substances, as in molding powdered Fe, the mold is moved axially during the compressing operation.

(1855) U. S. 2,259,465 (1941). C. Hardy (Hardy Metallurgical Co.), *Apparatus for Compressing Metal Powders.* A die as used in forming bearings from Cu or Sn has means for creating a vacuum.

(1856) Swiss 221,079 (1942). H. Förster, *Device for Pressing Metal Powders or Chips.* It consists of a cylindrical die and two counteracting punches, the die having means of enlarging or diminishing the diameter.

(1857) U. S. 2,276,453 (1942). A. F. Bandur (Western Electric Co.), *Lubricant Suitable for Dies Used in Compressing Materials for Magnetic Cores.* The dies are lubricated with stearic acid, spermaceti, lanolin and borax mixed with sufficient water to form a homogeneous emulsion of the ingredients.

(1858) U. S. 2,300,302 (1942). L. H. Morin and D. Marinsky, *Apparatus for Forming Castings from Metal Powders.* An apparatus having a pair of molds movable toward and from each other, and having a core arranged on the parting line of the molds and movable along the parting line.

(1859) German Appl. D. 91752 (1943). Deutsche Edelstahlwerke A. G., *Device for Pressing Powdered Materials.* It consists of a rubber chamber with a rubber stopper, the edge of the chamber being vulcanized to a steel pressure chamber under liquid pressure, and all three parts being covered by a counter pressure plate.

(1860) German Appl. D. 91707 (1943). Deutsche Edelstahlwerke A. G., *Die.* Rubber linings for dies used to mold solid forms from powdered metal are disclosed.

(1861) U. S. 2,309,828 (1943). W. Dalby (Chrysler Corp.), *Die Set.* A die set for sizing preformed articles has a punch carried by a ram, and works into a stationary die member; the punch has a formed plug in spaced relationship to the die member.

(1862) U. S. 2,336,982 (1943). G. D. Cremer (Hardy Metallurgical Co.), *Press.* A press particularly adapted to the compression of metal powders to form a coherent mass of predetermined shape uses a die plate with a bore, a first plunger in one end of the bore, springs fastening the die plate movable to a base, and a second plunger in the other end of the bore.

(1863) U. S. 2,338,491 (1944). I. B. Cutler (Baldwin Locomotive Works), *Press.* Compressing metal powders in a mold cavity with plunger is accomplished in a special press, whereby precision operation is obtained under large compressive forces, and means are provided for reaching the density and a dimensional control during operation of the press.

(1864) U. S. 2,342,037 (1944). G. D. Cremer (Hardy Metallurgical Co.), *Die Lubrication Method for Forming Various Alloy Compacts.* A thin film of flakes of Al, Cu or brass is attached to the die walls in a manner that flattens the flakes against the die walls, preparatory to compressing the powder in the die. The method is suitable for compressing Al and its alloy powders into parts that can be ejected and sintered.

(1865) U. S. 2,342,772 (1944). S. K. Wellman (S. K. Wellman Co.), *Stripping Apparatus.* It has a mold with an outer shell and an inner shell cooperating with each other to form an annular pressing chamber, and a plunger which is also annular in shape.

(1866) U. S. 2,348,197 (1944). W. Ernst (Hydraulic Development Corp.), *Briquetting Press.* An apparatus for molding granular material has a top and a bottom member, both movable relative to mold.

(1867) U. S. 2,358,765 (1944). M. N. Stadlin (Baldwin Locomotive Works), *Double-Acting Briquetting Press.* The press allows floating movements of the

mold in response to frictional contact between material to be briquetted and the mold walls.

(1868) U. S. 2,359,674 (1944). R. T. Pollock (Maguire Industries Inc.), *Press.* It has a plunger with a depression on a side face to facilitate escape of air from the die during molding.

(1869) U. S. 2,360,528 (1944). C. R. Talmage (General Motors Corp.), *Method of Making Powdered Metal Articles.* Articles with annular grooves from metal powders are produced with the aid of radial compression by means of rubber-like elastic die-members which move in a plane transverse to the movement of the punch.

(1870) U. S. 2,361,211 (1944). P. R. Kalischer (Westinghouse Electric & Mfg. Co.), *Lubrication of Dies.* Method of lubricating a die comprises application to the die surface of a coating of lubricant such as Mo-disulphide, W-disulphide, Mo-selenide, W-selenide or Mo-telluride. These crystalline plate-like compounds are arranged so that the metallic atoms are placed in a plane layer with a layer of non-metallic atoms (S, Se, Te) on each side.

(1871) U. S. 2,389,561 (1945). F. J. Stokes and L. H. Bailey (F. J. Stokes Machine Co.), *Press for Bearings.* A press for forming bushing bearings of powdered material employs a floating die with two plungers, whose rates of movement can be changed with respect to the die, to control the density of the pressed product.

(1872) U. S. 2,407,123 (1946). H. V. Allison, *Press.* A press for use in powder metallurgy has a pair of die plates in a die holder and a centrally located core projecting from the lower die plate.

(1873) U. S. 2,411,379 (1946). A. J. Langhammer (Chrysler Corp.), *Die Assembly for Making Briquettes.* A die assembly is disclosed for making briquettes from powders having a cylindrical body section and a tapered tip such as bullet cores and projectiles.

(1874) Brit. Appl. 26967/47 (1947). Boart Products, Ltd., *Press for Diamond Tools.* A press assembly is disclosed for the simultaneous mounting of diamonds in powdered metal compacts and joining the tips to the steel shank.

(1875) Brit. 596,866 (1948). F. J. Stokes Machine Co., *Molding Press.* In automatic presses having multiple-cavity dies an electromagnetic control is arranged for stopping the press, when a number of pressed parts is faulty.

(1876) Brit. Appl. 9082/48 (1948). S. K. Wellman Co., *Hydraulic Press.* A hydraulic press is used for making clutch linings requiring uniform density at high speed; the die parts are easily interchangeable.

(1877) Brit. Appl. 21607/48 (1948). American Electro Metal Corp., *Press for Shaping Blades from Metal Powder.* Gas turbine blades are made by a preshape, by means of a multiple-punch die; the compact is then sintered and given its final airfoil shape by coining, with intermediate annealing.

(1878) U. S. 2,437,127 (1948). L. D. Richardson (H-P-M Development Corp.), *Apparatus for Forming Pieces from Metal Powders.* A mold formed of low electrical conductivity material is surrounded with a coil for high frequency current, which permits heating the powder to sintering temperature after it is pressed into the mold by plungers.

(1879) U. S. 2,444,282 (1948). C. Creevy (Glaxo Laboratories Ltd.), *Die for Compressing Tablets.* The die consists of a porous metal supplying a lubricant under pressure to form a film at the inner wall of the compressing chamber; the die has a short non-porous part at the inlet end.

(1880) U. S. 2,449,008 (1948). H. A. Simpson (J. S. Pecker), *Means for Forming Pressed Articles.* A machine is disclosed with means for automatically measuring the amount of powder and manipulating the powder prior to the compression, so as to create separate areas of powder in relation to the finished article throughout the several required pressure operations.

(1881) U. S. 2,449,257 (1948). W. R. Tucker (H-P-M Development Corp.), *Press for Powdered Material.* The press incorporates a floating die, actuated by a controlled rate synchronous with the movement of the pressing plunger. During compaction, the die is moved in the same direction as the plunger, but at a slower rate.

(1882) Austrian 163,765; 163,923 (1949). Metallwerk Plansee G.m.b.H., *Hydraulic Press and Control Mechanism.* The press is fitted with several punches fitted in a movable ring and with punches for ejecting the products.

(1883) Brit. 610,011 (1949). American Electro Metal Corp., *Press for Compacting Metallic Powder.* Compacts having different thicknesses in the direction of pressing are compressed to equal density by providing individual sets of punches for each thickness. The length of the strokes are varied according to the compression ratio of powder.

(1884) Brit. Appl. 15933/49 (1949). Stora Kopparsbergs Bergslags A. B., *Mold for Production of Articles from Hard Metal Powder.* The dies are formed from mixtures of Bakelite and graphite as lubricating agent and are reinforced with a steel backing.

(1885) U. S. 2,465,204 (1949). H. W. Dalton, *Transfer Molding Press.* The press is intended for molding and can be applied to molding of plastics and metal powders. The injection plunger of the press is operated automatically immediately after the die is closed, by the same hydraulic pressure which operates the main die rams.

(1886) U. S. 2,485,283; 2,485,284 (1949). J. D. Guelph, *Ejector Mechanism for Molding Machines.* Invention provides an ejecting mechanism for a molding machine. It relates to various machines including powder metallurgy presses.

(1887) U. S. 2,485,336 (1949). E. I. Valyi, *Molding Machine.* A core plate and an ejector plate are associated with a die member carried by the movable clamp of an injection-molding machine and the invention provides separate means to actuate the core and ejector plates in desired sequence independently of each other and the stroke of the opening clamp. Invention can be applied to powder metallurgy pressing.

3. SINTERING

A. By Indirect Heating of Pressings

i. In Bath, Pack or Mold

(1888) U. S. 1,708,192 (1929). C. F. Sherwood, *Manufacture of Bodies From Metal Powder.* A dynamo brush with preformed conductor is made into an integral unit by pressing and sintering powdered metal in a bath of molten Na-salt having a melting point between 650° and 815° C. (1200° and 1500° F.).

(1889) Brit. 364,546 (1931). C. F. Sherwood, *Producing Porous Bodies.* A briquette of metal powders (*e.g.* Cu-Sn) and a volatile lubricant is sintered in a bath of molten metallic salt of reducing or non-oxidizing character (*e.g.* NaCN).

(1890) Canadian 333,621 (1933). C. F. Sherwood, *Sintering in Molten Salt Bath of Porous Metal Bearings. Cf:* U.S. 1,916,338 (No. 1891).

(1891) U. S. 1,916,338 (1933). C. F. Sherwood, *Sintering of Porous Metal Bearings.* Cu, Sn, Graphite and volatilizable lubricants are sintered in molten cyanide.

(1892) U. S. 1,927,626 (1933). W. G. Calkins (Chrysler Corp.), *Sintering of Metallic Material.* Porous bearings are produced by mixing powdered Cu (80%), Sn (10%) and Fe (10%), and stearic acid, compressing and sintering in a bath of Na-Al-fluoride.

(1893) Brit. 497,144 (1938). N. V. Philips' Gloeilampenfabrieken and J. Romp, *Method of Making Hard Metal Bodies.* It consists of embedding a molded body of WC and Co in a pulverulent mixture of a highly refractory inert substance plus an amount of carbon selected to produce a uniformly compact body, and heating the embedded body in a non-oxidizing atmosphere to sinter same.

(1894) U. S. 2,169,007 (1939). J. Romp (N. V. Philips' Gloeilampenfabrieken), *Method of Making Hard Metal Bodies. Cf.:* Br. 497,144 (No. 1893).

(1895) U. S. 2,207,708 (1940). C. W. Balke (Ramet Corp.), *Sintering Process for Hard Metal Alloys.* The process of making hard metallic bodies is improved by surrounding the bodies with loose particles of carbides of non-radioactive refractory metals before sintering.

(1896) French 866,951 (1941). L. Renault, *Sintering of Hard Metal Pieces.* The sintering takes place in crucibles of graphite filled with graphite powder and in H_2 atmosphere.

(1897) Brit. 554,413 (1943). B. Landau, *Heating of Metal Carbides.* Metal carbide powder is introduced into a mold of graphite and heated in electrical resistance furnace to above melting point of the carbide, then cooled rapidly to prevent crystallization.

(1898) Belgian 450,005 (1944). Deutsche Edelstahlwerke A. G., *Production of Sintered Bodies Sensitive to Oxidation. Cf:* German 762,089 (No. 1901).

(1899) U. S. S. R. 64,664 (1944). I. A. Alexejev, *Sintering Method.* Sintering is performed in boats consisting of Al_2O_3, graphite, and $CaCO_3$. A CO atmosphere is maintained by reaction of the graphite with CO_2 liberated from the carbonate at sintering temperatures.

(1900) German 750,820 (1945). Deutsche Edelstahlwerke A. G., R. Kieffer and W. Hotop, *Equipment for Sintering of Magnets.* The furnace with heating elements of Mo or Ta has a sliding plate of graphite with a support of sintered Al_2O_3 for the boat, in which the magnets are sintered at 1400° C. (2550° F.). A layer or pack of loose Al_2O_3 or SiO_2 may also be interposed between the magnet and graphite base.

(1901) German 762,089 (1945). Deutsche Edelstahlwerke A. G., R. Kieffer and W. Hotop, *Production of Sintered Bodies Sensitive to Oxidation.* Permanent magnet compositions are sintered in Fe vessels inside powder packs of ferro-aluminum (20-30% Al) which functions as a getter.

(1902) Swiss 235,323 (1945). Deutsche Edelstahlwerke A. G., *Production of Sintered Bodies with Sensitivity against Oxidation.* The protective gas is cleaned by filtering it with Fe-Al powder in the neighborhood of the sintering body.

(1903) Brit. 584,471 (1947). K. J. Forrest, *Protection of Metal Alloys during Heat Treatment.* Protection is obtained by an alkaline earth metal, *e.g.* Mg or an alkaline metal, enclosed in the metal or alloy, and by heat treating in a vessel.

ii. In Controlled Atmosphere

(1904) U. S. 1,110,303 (1914). H. Kreusler (General Electric Co.), *Hard Alloy.* A mixture of 90 parts W and 10 parts Ni are heated in powdered form in H_2 atmosphere to 1510° C. (2750° F.), whereupon heating is interrupted.

(1905) U. S. 1,359,353 (1920). C. L. Gebauer, *Method of Producing Formed Metallic Articles.* It comprises compacting a finely divided metallic substance or a mixture of metal powders under great pressure and then heat treating above the critical temperature of all constituents, but below their fusing temperature until the particles cohere rigidly together.

(1906) French 671,626 (1929). I. G. Farbenindustrie A. G., *Metallic Pieces from Powdered Metals.* They are obtained by compression and sintering in a reducing atmosphere.

(1907) French 675,666 (1929). I. G. Farbenindustrie A. G., *Sintering of Iron.* Sintering of Fe with reducible compounds under reducing conditions is claimed.

(1908) Brit. 327,955 (1930). I. G. Farbenindustrie A. G., *Treating Metal Scrap.* Scrap, such as sheet Fe is mixed with metal powder, and material is pressed and heated in an inert or reducing atmosphere.

(1909) Brit. 366,059 (1932). I. G. Farbenindustrie A. G., *Sintering of Metals and Alloys.* During sintering, small amounts of slag forming material are added, and excess impurities are removed by treating with a reducing gas.

(1910) U. S. 1,922,402 (1933). C. R. Short (Moraine Products Co.), *Method of Sintering Briquetted Metals.* The method comprises rapidly heating the article to a temperature near a predetermined sintering temperature, first exposing the article to a higher than the sintering temperature, and then immediately passing it into the sintering zone.

(1911) Brit. 406,124 (1934). E. O. Saint-Jacques, *Heat Treating of Powdered Material.* The used gas in sintering supports the combustion.

(1912) Brit. 488,296 (1938). G. Zotas, *A Process of and Means for the Manufacture of Carbides and Other Oxidizable Substances.* A rotary cylindrical furnace with circulating furnace gases and a combustion zone in the furnace for heating material by radiation are claimed.

(1913) German 657,093 (1938). F. Skaupy, *Production of Dense Metallic Bodies.* The process comprises the application of vapors of Hg as an inert filling atmosphere in vessels for metallurgical processes such as for the producing of dense metallic bodies by sintering or melting.

(1914) Brit. 506,486 (1939). N. V. Wallramite Handel Maatschappij, *Apparatus for Obtaining Coherent Masses from Powdered Metals.* Sintering in an electric furnace with conveyer under controlled atmosphere is claimed.

(1915) German 682,889 (1939). H. Farsky, *Furnace for Sintering Hard Metals.* Sintered hard metallic bodies are produced by reduction of the metallic binding agent, whereby the reducing gas is going in circulation through the sintered bodies.

(1916) U. S. 2,181,097 (1939). H. J. Ness (Nesaloy Products Inc.), *Furnace.* Its construction permits applying to the refractory body of the furnace a suspension of a lithium compound, and heating the furnace to a temperature to produce a lithium component in the furnace atmosphere.

(1917) Danish 57,331 (1940). Allgemeine Elektrizitäts Gesellschaft, *Furnace for Continuous Production of Sintered Alloys.* Continuous production of light, oxidizable metals, such as Al with Fe and W occurs on belts running through a tubular furnace, in H_2 atmosphere, having a high heating zone of 1400° C. (2550° F.) and a low heating and cooling zone of 600° C. (1110° F.)

(1918) German 688,269 (1940). Deutsche Gold- & Silberscheideanstalt and W. D. Jones, *Production of Coherent Masses for Metallic Objects.* Sintering is conducted in the presence of metal hydrides such as Ca-hydride, Ti-hydride or alkali-metal hydrides to prevent oxidation during heat-treatment.

(1919) U. S. 2,197,642 (1940). G. H. Howe (General Electric Co.), *Furnace.* In an electric furnace for sintering of permanent magnets, H_2 atmosphere is purified to an unusually high degree, to temperatures of up to 1400° C. (2550° F.).

(1920) Austrian 160,009 (1941). E. Schattaneck, *Production of Porous Bodies.* The sintering of the metal particles occurs at 5-25° C. (10-45° F.) below the melting point of the metal for 10-25 min. in a controlled atmosphere.

(1921) U. S. 2,263,520 (1941). J. Romp (Hartford National Bank), *Method of Making Sintered Hard Metal Alloys.* High-density bodies are made by increasing the pressure of the protective atmosphere during sintering.

(1922) German 723,621 (1942). Vereinigte Deutsche Metallwerke A. G. and H. Burkhardt, *Procedure for Alloying Low-Melting Metals Such as Lead or Cadmium with High-Melting Metals Such as Iron or Copper.* The metals in the form of reducible compounds are mixed together and sintered above the melting point of the low-melting metal and exposed to a reducing atmosphere.

(1923) U. S. 2,271,091 (1942). J. S. Pecker and H. A. Simpson (Machine & Tool Designing Co.), *Apparatus for Heat Treating and Sintering.* The apparatus has means for sintering, cooling and varying the temperature of the article during their continuous traverse through the system.

(1924) Brit. 556,561 (1943). Birmingham Electric Furnace Ltd. and P.F. Hancock, *Gaseous Atmosphere for Use with Heat Treatment.* An atmosphere containing

5-75% of a mildly carburizing gas, and 95-25% of a mildly decarburizing gas is used in furnaces for sintering Fe or Fe alloys.

(1925) U. S. 2,330,438 (1943). C. A. Mann (General Motors Corp.), *Sintering Furnace.* A tunnel-like sintering furnace is divided in three compartments connected with conveyers and with a tank of molten metal in the second compartment.

(1926) Swiss 233,293 (1944). Deutsche Edelstahlwerke A. G. and R. Kieffer and W. Hotop, *Continuous Tube Furnace for Production of Sintered Bodies.* The support is made of graphite glides on a grate; a ceramic rest serves for the metallic tray.

(1927) U. S. 2,346,698 (1944). H. J. Ness, (Metallurgical Processes Co.), *Producing Protective Atmospheres.* Process comprises generating a carrier gas, cooling it to eliminate water vapors, heating a composition of lithium to produce vapor, which is mixed with the carrier gas and introduced in furnace.

(1928) U. S. 2,354,523 (1944). R. P. Koehring (General Motors Corp.), *Heat Treating Apparatus.* A bell-type heat treating furnace with a rotating table and protective atmosphere is disclosed.

(1929) Brit. 571,317 (1945). Murex Ltd. and G. L. Miller, *Alloy by Sintering in Protective Atmosphere.* Sintered alloys are produced from pressed mixtures of metal powders containing one readily oxidizable metal or alloy, by pressing the metal powders, sintering them *in vacuo* or non-oxidizing atmosphere, and protecting them by the presence in the sintering zone of a porous material functioning as getter, which is oxidized by O or H_2O.

(1930) Brit. Appl. 34523/46 (1946). D. Primavesi, *Production of Metal Parts.* Pressings of oxide powders are reduced and sintered in a reducing atmosphere in one operation with or without subsequent coining, rolling or forging.

(1931) Brit. 585,052 (1947). Standard Telephone & Cables Ltd., *Electric Furnace.* A sintering furnace for temperatures up to 2000° C. (3630° F.) comprises a tube of refractory material with helical grooves cut on the inside of the tube for fitting heating wires and means for supplying multi-phase electric currents.

(1932) U. S. 2,431,690 (1947). R. D. Hall and J. H. Ramage (Westinghouse Electric Corporation), *Consolidation of Refractory Metal Powders.* Method of consolidating metal powders of Mo or W to form a dense coherent metal involves heating the pressed shape for a long time in a reducing atmosphere of H_2 to a temperature not exceeding 70% of that of fusion, the H_2 atmosphere being saturated with water vapor between 20 and 40° C. (68 and 104° F.).

(1933) U. S. 2,431,691 (1947). W. J. Newman (Westinghouse Electric Corp.), *Method for Consolidating Refractory Metal Powders to Dense Coherent Form.* Process described in U.S. 2,431,690 (No. 1932) is expanded to include the manufacture of very large pieces of work, mainly of Mo, the principal new feature being the support of the heavy compacts by transversely corrugated Mo plates of high degree of resilience during sintering in moisture-conditioned H_2 atmosphere.

(1934) Brit. 601,057 (1948). Westinghouse Electric International Co., *Consolidating Metal Powders to Dense Coherent Form.* Sintering of W or Mo occurs in moist H_2 atmosphere to produce a reversible oxidizing/reducing reaction. The sintering of Fe or Cu occurs in an atmosphere of NH_3 and H_2 with the formation of a nitride.

(1935) Swiss 251,459 (1948). Murex Ltd., *Production of Sintered Bodies.* Oxidizable metal powders are protected against oxidation during sintering by adding Si, Cr, Al, Ti powder which forms an oxide not reducible by H_2 atmosphere.

(1936) Austrian 162,286 (1949). Metallwerk Plansee G.m.b.H., *Continuous Sintering Furnace with Water Cooling.* The controlled atmosphere furnace has 22° angle of incline, and is tilted at the charging and discharging end.

(1937) Austrian 162,295 (1949). Metallwerk Plansee G.m.b.H. and F. Krall, *Continuous Furnace Suitable for Sintering.* The indirectly heated vertical furnace tube of C carries the electrodes in an acute angle; these electrodes are surrounded at ¾ of their length by C tubes which are at some distance from the electrodes for insulation.

(1938) Brit. 617,849 (1949). Metal-Gas Co. Ltd. and C. A. K. Bolton, *Articles from Ferrous Metal Powders.* Ferrous pressings are sintered in an atmosphere containing $CrCl_2$ which may be produced from HCl and metallic Cr; a porous ceramic may be mixed with the Cr lumps.

(1939) Swiss 264,362 (1949). Metallwerk Plansee G.m.b.H., *Continuous Furnace with Water Cooling. Cf.:* Aust. 162,286 (No. 1936).

(1940) U. S. 2,485,782 (1949). H. C. Schweitzer (Associated Metals & Minerals Corp.), *Furnace for the Heat Treatment of Solids.* The invention provides a large capacity furnace which can be adapted to any of a variety of continuous high temperature treatment of solids, including the sintering of metal powder compacts.

(1941) U. S. 2,489,459 (1949). H. J. Ness and C. E. Thomas (Metallurgical Processes Co.), *Metallurgical Furnace.* Furnace is associated with a forming press or other work processing mechanism, as is encountered in powder metallurgy work. A plurality of work parts are simultaneously heated in a protective atmosphere and any of the parts may be removed and replaced by other parts without modifying or contaminating the atmosphere to which the remaining parts are subjected.

iii. In Vacuum or Electrically Charged Gases

(1942) Brit. 274,283 (1927). Metropolitan-Vickers Electrical Co. and N. R. Davis, *Sintering of Refractory Metals.* Process comprises slowly heating a pressed powdered body and later cooling it in high vacuum, then heating it quickly to sintering temperature.

(1943) German 488,583 (1929). Hartstoff Metall A. G., *Pressings for Bearings.* The pressing is heated *in vacuo* before the sintering starts.

(1944) Austrian 138,748 (1934). P. Schwarzkopf, *Production of Sintered Bodies of Alloys.* The cold pressed compacts are agitated repeatedly *in vacuo* and in a reducing atmosphere, and are mechanically worked after each step.

(1945) French 781,642 (1935). Vereinigte Edelstahl A. G., *Sintering of Alloys.* Mixtures of powdered metals are submitted several times under vacuum or in a reducing atmosphere to a thermal treatment and heat treatment until the product is free of pores.

(1946) French 793,020 (1935). M. Goldenzweig, *Method of Sintering Carbides Under Different Pressures.* The powdered mixture of carbides and metallic binders is introduced into a C-mold and heated in a furnace to 1600-2000° C. (2910-3630° F.) under high vacuum. When the binder is fused, a pressure of 20-100 atm. is exerted.

(1947) Italian 325,703 (1935). Vereinigte Edelstahl A. G., *Production of Sintered Alloys. Cf.:* German 635,644 (No. 1948).

(1948) German 635,644 (1936). Vereinigte Edelstahl A. G., *Sintering Metal Alloys.* Alloys (*e.g.* of refractory metals, such as W-Ta and W-Cb, are powdered, pressed, sintered *in vacuo*, worked and resintered in reducing atmosphere.

(1949) German 635,703 (1936). Vereinigte Edelstahl A. G., *Production of Sintered Alloys.* The powder pressings are sintered alternately in vacuum and reducing atmosphere and worked between the steps to produce a non-porous body.

(1950) Italian 364,899 (1938). B. Berghaus, *System and Apparatus for the Sintering of Hard Materials in Vacuo.* In a method of manufacturing metal parts, especially hard materials, from metal powders, the compacts are exposed, in a vacuum, to marked heating, by being made to function as a cathode of a discharge in gas, preferably that of the "efflux" type.

(1951) Brit. 504,249 (1939). B. Berghaus, *Manufacture of Bodies from Metal Powder.* Bodies of compressed hard powder substances are heated and sintered by subjecting them to an electric glow gas discharge in vacuum, the sintered bodies being connected up as one of the electrodes.

(1952) French 841,904 (1939). B. Berghaus, *Sintering of Pressings.* The pressings are used as cathode in vacuum discharge tubes so that the glow-light completely surrounds the pressings.

(1953) French 842,197 (1939). B. Berghaus, *Procedure and Apparatus for the Manufacture of Metallic Articles By Fritting of Metal Powders. Cf.:* Brit. 504,249 (1939).

(1954) Italian 373,074 (1939). B. Berghaus, *Sintering of Pressings.* A process is disclosed which uses the pressings as anode in an electrical discharge in *vacuo.*

(1955) Brit. 528,320 (1940). B. Berghaus, *Improvement in and Relating to the Manufacture of Sintered Bodies from Metal and Compound Powders.* Addition to Brit. 504,249 (1939). Articles of pressed hard powders, *e.g.* cemented carbides, are subjected to an electric glow gas discharge at a reduced pressure, with the powder compacts being connected as an anode for the purpose of being heated and sintered.

(1956) French 853,152 (1940). B. Berghaus, *Sintering Powder Metals.* The electrical gas discharge method is used for the sintering of metal powders, by connecting the powder compacts as anode and using the metallic mirror of the discharge chamber, which is under vacuum, as cathode.

(1957) U. S. 2,227,176; 2,227,177 (1940). B. Berghaus and W. Burkhardt, *Method of Sintering Hard Substances in Vacuum.* A method of manufacturing relatively hard metal articles from metal powder comprises pressing the powder into desired shape, supporting the shaped powder within and insulated with respect to a sealed electrically conducting housing, evacuating the housing to remove gases therefrom, introducing an inactive gas into the housing, and impressing a voltage across, and an electrode within the housing, to create a glow discharge around the powder pressing to sinter it into shaped articles.

(1958) French 865,906 (1941). Gesellschaft zur Förderung der Forschung auf dem Gebiet der Technischen Physik, *Production of Hard Metals.* The mixture of refractory carbide and auxiliary metal is sintered first in H_2 and then *in vacuo.*

(1959) German 704,254 (1941). B. Berghaus and W. Burkhardt, *Vacuum-Furnace for Sintering Objects Made of Metallic Powders.* Method of producing hard metal bodies comprises agitating the pressed bodies by means of a gas discharge, so that the bodies are active as a cathode during heating.

(1960) German 743,420 (1943). B. Berghaus and W. Burkhardt, *Sintering Powder Metals.* The pressed powdered metals are wired as anodes or are kept neutral in an electrical glow discharge apparatus used for sintering.

B. By Direct Heating of Pressings

i. By Electrical Resistance

(1961) U. S. 942,513 (1909). R. Palmer, *Sintering Apparatus.* It has a container, means for supplying gas thereto, means for clamping the body of refractory metal to be sintered by electric current, and means for passing a cooling fluid through the clamps.

(1962) U. S. 1,071,488 (1913). G. Weintraub, H. Rush (General Electric Co.), *Apparatus for Sintering Refractory Metals.* It consists of confining the material within a given space by an inert substance of high electric and heat insulating properties, and exerting an acting pressure, while passing electric current through the material.

(1963) German 295,518 (1916). Julius Pintsch A. G. and C. Reinhold, *Sintering of Filaments.* The Hg contacts are cooled with a gas stream at the place where they are connected with the filament, to prevent the formation of an arc.

(1964) U. S. 1,273,920 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Electric Sintering Furnace.* It comprises a heating chamber with a cradle to support an ingot under treatment; the cradle consists of a pair of W rods of fibrous structure, connected to an electric circuit.

(1965) French 519,125 (1921). E. Aoyagi, *Device for Making Ductile Tungsten.* The W bars are suspended into a vessel containing H_2 and heated electrically until the elongated bars close a contact, which interrupts the current.

(1966) Brit. 183,120 (1923). General Electric Co., *Ingots of Refractory Metals.* Preparation of ingots of refractory metals, which consist of particles having one or a small number of crystals, comprises pressing them and subjecting them to a temperature in the region of the melting point until a change in the crystalline structure results.

(1967) German 380,719 (1923). Pfanstiehl Co., *Furnace for Sintering of Tungsten.* The preformed bar is connected with the electrodes which are then pressed against the bar, before the current is passed through the bar.

(1968) Brit. 217,322 (1924). S. G. S. Dicker, *Refractory Metals for Wires or Filaments.* A method of rendering W or Mo ductile consists in sintering the metal by direct resistance in the presence of preheated H_2.

(1969) German 436,146 (1926). Patent Treuhand Gesellschaft für Elektrische Glühlampen, *Electric Furnace.* Electric furnace with isolated lining consisting of porous W, which functions as electrical resistor element.

(1970) Brit. 354,785 (1931). General Electric Co. Ltd. and C. J. Smithells, *Sintering Metals Such As Tungsten.* W is sintered at a temperature slightly below its melting point in an atmosphere containing a vapor of another metal, such as Na, and an inert gas or H_2.

(1971) U. S. 1,925,292 (1933). R. Walter, *Method of Sintering Metallic Bodies.* The bodies to be sintered are moved mechanically between the heating surfaces of an electrical resistor furnace with constant movement of rotation.

(1972) U. S. 1,932,499 (1933). G. Woods (Hughes Tool Co.), *Electric Furnace for Manufacturing Fine Grained Tungsten Carbide.* An electric furnace is disclosed which has upper and lower conducting plates, means to cool the plates, and a graphite crucible between the plates; the upper plate has an opening to receive the carbide in form of bits, and a laterally curved box below the crucible is adapted to cool the carbide quickly.

(1973) Austrian 144,896 (1936). A. Kratky, *Sintering Method for Carbides and Other Refractory Compounds.* A rod is compacted from carbides or nitrides or alloys of refractory metals or metalloids, and is subjected to high amperage resistance sintering.

(1974) Austrian 146,365 (1936). A. Kratky, *Fusing Or Effecting Reaction in Pulverulent Materials.* The powders are passed through hollow electrodes and sintered by resistance heating.

(1975) French 881,982 (1943). Deutsche Gold- und Silberscheideanstalt, *Method of Production of Sintered Bodies. Cf.* Swiss 226,967 (No. 1976).

(1976) Swiss 226,967 (1943). Deutsche Gold- und Silberscheideanstalt, *Method of Production of Sintered Bodies.* The sintering effect is produced on pressings at temperatures above the melting point, *e.g.* at temperatures of the electric arc, by exposing the pressings to the heating during a very short time.

(1977) U. S. 2,358,090 (1944). A. Longoria (Unit Rays Inc.), *Bonding Powdered Metals.* Bonding of powdered Stellite to the tapered seating surface of valve bodies is accomplished by direct electrical heating of the lower melting metal powder surrounding the conical portion of the valve, and enclosed within a mold.

ii. By High-Frequency Current

(1978) German 405,880 (1924). A. Uhlmann, *Production of Bodies of Metal Powders.* The metal powder is sintered by using high frequency eddy currents.

(1979) U. S. 1,691,349 (1928). G. F. Harrington and P. H. Brace (Westinghouse Electric & Mfg. Co.), *High-Frequency Induction Furnace.* Furnace for heating a continuous train of articles of uniform size consists of two inductor coils.

(1980) Brit. 405,983 (1934). A. Uhlmann, *Articles From Metal Powders.* Method of production of W, Ti, or B carbides, W-Co, Fe-Cu or Cu-Al alloys, comprises pressing the powders to shape, exposing them to a gaseous atmosphere of oil gases or vapors, and to the action of a high-frequency field.

(1981) Brit. 452,411; 452,503 (1936). V. Sauter and F. Klonnik, *Coherent Masses From Powdered Metals by Sintering.* A mixture of granular and powdered metal is subjected to high-voltage in a high-frequency field.

(1982) Swiss 181,867 (1936). V. Sauter, *High Frequency Coil.* It is produced from a mixture of powdered Cu and Ag and at least two metals of the 4th to 8th groups of the periodic system and sintered in an electromagnetic field of high frequency.

(1983) German 692,553 (1940). W. Koehler, *Shaped Molds for Centrifugal Casting.* A method of producing shaped molds for centrifugal casting from metal powders mixed with non-metallic powders is based on influencing the mixture with eddy currents of high frequency and simultaneously influencing the mixture by centrifugal action on the mold which is surrounded by the high frequency coil.

(1984) Swiss 213,770 (1941). Gesellschaft zur Förderung der Forschung auf dem Gebiete der Technischen Physik an der Eidgenössischen Technischen Hochschule, Zürich, *Sintering Hard Metals in High Frequency Furnace.* A method of sintering metal powders in a high frequency field of forces and in atmosphere containing C is disclosed.

(1985) U. S. 2,228,600 (1941). C. Hardy (Hardy Metallurgical Co.), *High-Frequency Sintering.* The use of eddy currents serves to reduce distortion of powder metal briquettes during the bonding operation, and to accelerate diffusion.

(1986) U. S. 2,235,835 (1941). C. G. Goetzel (Hardy Metallurgical Co.), *Powder Metallurgy.* A high frequency induction furnace is disclosed which enables the accurate sintering of metal powder compacts without temperature control devices.

(1987) U. S. 2,247,370 (1941). C. G. Goetzel (Hardy Metallurgical Co.), *Induction Furnace for Sintering.* Bonding particles of powdered metals such as Cu, Sn, Fe, is accomplished by influencing wave length and frequency to an extent, that electric power input and temperature of sintering can be controlled without temperature control devices.

(1988) Swedish 104,543 (1942). Kohle- und Eisenforschung G.m.b.H. and W. Bischof, *Method of Accelerating the Sintering Process in the Sintering of Powders.* The method is characterized in that the materials, especially metal powders, are exposed to the action of supersonic waves during sintering. The action of ultrasound takes place at temperatures below the regular sintering temperature, down to the temperature of recrystallization. Before this treatment, the powder may be pressure-worked (compressed).

(1989) U. S. 2,341,739 (1944). R. G. Olt (General Motors Corp.), *Method of Making Porous Metals.* Hollow cylindrical porous metal articles are produced by induction heating while the die is being rotated.

(1990) Swiss 234,822 (1945). Radiamant A. G., *Sintered Metal Articles.* A homogeneous, very fine grained dense product is obtained by use of high frequency current during sintering. Alternate intervals of low frequency may be used.

iii. By Exothermic Processes (Thermite)

(1991) U. S. 2,056,708 (1936). G. Boecker, *Process of Producing Hard Metal Alloys.* Metals are alloyed in a closable carbon crucible surrounded with thermite and refractory mass; sintering or fusing of the metal occurs by burning the thermite, and suddenly cooling to effect a high compression of the contents of the crucible by internal pressure.

(1992) **U. S. 2,097,502** (1937). G. T. Southgate (Union Carbide & Carbon Corp.), *Method of and Apparatus for Producing Rods and the Like of Comminuted Material.* The method consists of compressing comminuted material into rod form, and heating successive portions of it to fusing temperature, with at least part of the heat being supplied by the exothermic reaction of the comminuted substances.

(1993) **Brit. 544,888** (1942). The Glacier Metal Co., Ltd., P. T. Holligan, and W. B. D. Brown, *Bonding Metals.* Bonding of steel and Al in powdered and sintered form is accomplished by producing an exothermic reaction at the surfaces.

C. By Heating Without Previous Compacting (Thermal Compacting)

(1994) **German 229,016** (1910). O. Schaller, *Sintering of Metal Powders.* A paste, made of the metal powders and binder, is formed to a body which is used as cathode in an electrolyte after the method of Lagrange and Hoho, by which the paste is rendered conductive in a current carrying fluid, so that the metal particles of the paste are sintered by heating.

(1995) **Austrian 94,522** (1923). Lohmann-Metall G.m.b.H., *Production of Bodies of Tungsten Carbide.* The carbide powder is filled in forms of graphite and heated without pressure until crystallization starts.

(1996) **Swiss 100,240** (1923). Westinghouse Lamp Co., *Production of Coherent Masses.* Powders of refractory metals or their alloys or oxides are heated very slowly *in vacuo* for the elimination of gases, and then heated for sintering.

(1997) **Swiss 138,072** (1930). I. G. Farbenindustrie A. G., *Method for Production of Bodies from Metal Powders.* Loose masses of Fe or Ni powder, produced from their carbonyls, are sintered without melting.

(1998) **Belgian 368,063** (1931). I. G. Farbenindustrie A. G., *Production of Porous Masses.* Metal powder is agglomerated by first heating it at a relatively low temperature; then a second agglomeration occurs at a higher temperature in inert or reducing atmosphere.

(1999) **Brit. 354,562** (1931). I. G. Farbenindustrie A. G., *Sintering Shaped Masses Comprising Metal Powders.* To prevent cracking, the pulverulent material is placed during sintering so that the direction of greatest shrinkage is substantially vertical. The interior of the mold is coated with a refractory material such as graphite.

(2000) **French 712,462** (1931). I.G. Farbenindustrie A.G., L. Schlecht and W. Schubardt, *Production of Shaped Metallic Articles by Sintering.* Sintering metallic powders by heat occurs in a form allowing the arranging of uncompressed metallic powder in such position that the direction in which shrinkage during sintering is the greatest is about vertical.

(2001) **German 564,253** (1932). I. G. Farbenindustrie A. G., F. Duftschmid, L. Schlecht and W. Schubardt, *Method of Making Shaped Parts from Powdered Metals.* Method of making shaped parts by sintering the powder mass in a mold in such a position that the direction of the largest shrinkage is vertical.

(2002) **U. S. 1,882,972** (1932). I. G. Farbenindustrie A. G., L. Schlecht and W. Schubart, *Production of Shaped Metallic Articles by Sintering. Cf.:* French 712,462 (No. 2000).

(2003) **French 780,081** (1935). G. Boecker, *Sintering of Metal Powders.* The powders are sprayed out by a nozzle with the aid of H_2 or N_2 as carrying gas and are mixed with a binding material sprayed by a second nozzle, to produce bodies of great toughness without cracks in a subsequent sintering operation.

(2004) **German 608,122** (1935). I. G. Farbenindustrie A. G., *Production of Porous Bodies.* The metal powders are presintered at 650° C. (1200° F.) to make the powder mass plastic; the mass is then sintered at 800-1200° C. (1470-2190° F.).

(2005) **Austrian 144,356** (1936). Siemens & Halske A. G., *Production of Sintered Formed Hard Bodies.* Powders of carbides of W, Mo, Ti, Ta are mixed with a

binder such as Co and an electrolyte, which consists of Co nitrate, glycerine and water; the mass is poured into a form of gypsum to produce on the walls of the form a layer; the form is filled by repeating the procedure, and then the body is sintered.

(2006) French 801,730 (1936). I. G. Farbenindustrie A. G., *Production of Formed Bodies.* The metal powders are filled into molds which are moved through a vertical tube, which is fitted with heating and cooling devices, and is passed by an inert atmosphere.

(2007) Swiss 181,007 (1936). G. Boecker, *Sintered Hard Metal Bodies.* A powdered mixture of hard metal carbide and auxiliary metal is sprayed out of one nozzle, and an organic binder out of a second nozzle, to fill a form with the mixture, which then is sintered.

(2008) French 816,989 (1937). N. V. Wallramit Handel Maatschappij, *Formed Bodies Containing Hard Metal.* The powdered metal is filled into a mold to form the article and its surface is protected by a screen of metal with high melting point, *e.g.* Mo, and the mass is then heated without application of pressure.

(2009) Swiss 204,922 (1939). Spladis Soc. Pour L'Application D'Inventions Scientifiques, *Sintering of Refractory Metal Powders.* The powder is first burned in a mold, to make the particles agglomerate; then the mass is sintered at elevated temperatures and simultaneously centrifuged.

(2010) German 692,533 (1940). Deutsche Eisenwerke A. G., *Production of Molds for Centrifugal Casting.* The metal powders or chips are sintered in a form which is surrounded by a high-frequency coil and which is rotating during the heating.

(2011) U. S. 2,217,802 (1940). R. P. Koehring (General Motors Corp.), *Sintering of Loose Metal Powder in Special Mold Equipment.* The method comprises molding the metal powders by loosely filling the material into a mold whose surface includes Cr, placing the mold in a sintering furnace having a non-oxidizing atmosphere including a small quantity of water vapor, heating the mold sufficiently to cause the metal powder to sinter and form a porous metal article and simultaneously to cause the surface of the mold to become oxidized with an oxide of Cr, and then removing the porous article from the mold.

(2012) U. S. 2,227,308 (1940) J.M. Hildabolt (General Motors Corp.), *Method of Molding Metal Powders.* It permits the making of porous cored metal objects by sintering uncompacted metal powders in a suitable mold.

(2013) Swiss 217,550 (1941). Kohle- und Eisenforschung G.m.b.H., *Method of Sintering of Powders.* The metal powders are agitated during sintering by ultrasonic waves at a temperature below the normal sintering temperature, causing a violent heating on the contact surfaces of the particles.

(2014) Brit. 544,833 (1942). R. G. Olt, *Porous Metal Body.* A method for reducing the shrinkage during sintering of porous articles from non-compacted metal powders containing particles of two constituents of different melting points, comprises one powdered constituent whose particle surfaces are rich in the constituent of the lowest melting metal.

(2015) Swiss 217,550 (1942). Kohle & Eisenforschung G.m.b.H. and W. Bischof, *Method for Sintering of Metal Powders.* During sintering the metal powders are agitated with ultrasonic vibrations, to accelerate the sintering process.

(2016) U. S. 2,302,660 (1942). W. H. Bagley and C. E. Eggenschwiler (Bohn Aluminum & Brass Co.), *Sintering of Powdered Metal Bearings.* Individual cooled bearing shells, charged with unmelted bearing metal in finely divided condition, are periodically introduced into a hot non-oxidizing atmosphere and withdrawn after completing their traverse along the path of the atmosphere, in order to sinter the powdered metal into a coherent mass.

(2017) U. S. 2,309,018 (1943). A. R. Shaw (General Motors Co.), *Sintering of Composite Strip Stock.* Method of making porous metal articles comprises distributing a loose non-compacted layer of metal powder upon a flat moving surface and a supporting surface moving in the same direction, and sintering it into a uniform porous layer.

(2018) U. S. 2,341,739 (1944). R. G. Olt (General Motors Co.), *Method of Making Porous Metals.* Cylindrical porous articles are made by distributing metal powders into cylindrical form, and holding them in place centrifugally while sintering.

(2019) U. S. 2,384,654 (1945). S. A. Smith (Federal Mogul Corp.), *Process of Fabricating Babbitt-Lined Bearings.* A bearing shell rotates and simultaneously a vibration is applied to assist in the even spreading of Cu or other metal powders on the inner surface of the shell, which is heated to a dull red heat, so that the metal powder will sinter into a spongy layer.

(2020) U. S. 2,390,160 (1945). J. T. Marvin (General Motors Corp.), *Method of Manufacture.* Hollow objects are formed from non-compacted metal powder with a volatile organic solvent and a binder by sintering to decompose the binder.

(2021) Italian 427,651 (1948). Soc. Anon. Italiana Ferro., *Metallic Agglomerate.* Metal powders, produced from their carbonyls, are agglomerated to blocks at a temperature below the melting point and without compression, by a special mixing movement in a closed vessel in the presence of an inert or reducing gas.

(2022) U. S. 2,478,856 (1949). W. W. Beaver (Battelle Development Corp.), *Method of Recovering Surface Permeability of a Porous Body.* A mixture of metallic powders and a dispersing agent is formed, poured into a mold and the powder is allowed to settle. Excess liquid in the mold is decanted, and the remaining agent is evaporated. The mass of metallic powder is sintered in the mold under reducing conditions and the sintered, porous body is removed from the mold and machined.

4. COMBINED PRESSING AND SINTERING

A. Hot-Pressing

(2023) U. S. 863,134 (1904). S. Axelrod (General Electric Co.), *Process of Treating Metal Chips.* Metal chips are heated to approximately 500° C. (930° F.) and pressed to strain the metal beyond the elastic limit.

(2024) German 192,261 (1907). A. Schwieger, *Fabrication of Ingots.* Fabrication of ingots is accomplished by means of bringing metal scrap in a heated cylinder provided with pressing piston.

(2025) Brit. 22,041/1912 (1913). H. Leiser, *Process for the Manufacture of Solid Bodies from Powder.* It comprises heating and compressing a mixture of more than 90% of crystalline metal powder and less than 10% of amorphous metal powder to convert the amorphous into crystalline metal.

(2026) U. S. 1,074,993 (1913). C. Trenzen, *Method of Rendering Insufficiently Ductile Metals Ductile.* W is rendered ductile by heating the amorphous metal powder to a high temperature and pressing it at the moment of heating when the metal would crystallize.

(2027) German 274,137 (1914). A. Mauser, *Production of Metal Alloys.* The powders of a high melting metal are pressed below the surface of a molten lower melting metal.

(2028) German 289,864 (1915). Allgemeine Elektrizitäts Gesellschaft A. G., *Method of Producing Homogeneous Bodies.* Method of producing homogeneous bodies comprises embedding pulverulent boron and tungsten carbides in a thermic and electric insulating material, followed by sintering and simultaneously pressing the body.

(2029) U. S. 1,141,469 (1915). H. Leiser, *Process for the Manufacture of Solid Bodies from Powder. Cf.:* Brit. 22,041/1912 (No. 2025).

(2030) U. S. 1,155,652 (1915). W. J. Goeglein and E. A. Colburn, Jr., *Process of Forming Metal Sprouts.* Forming metal in a divided condition into a sprout comprises heating to coalescence while the metal is being formed into a predetermined design.

(2031) French 485,551 (1918). M. J. Insull, *Apparatus for Treating Ingots of Tungsten.* It contains a form in which the W powder is pressed and simultaneously electrically heated in a furnace.

(2032) German 335,079 (1921). G. Ising and H. Borofski, *Pressed Articles.* Metal in powder form is brought into shape by converting it into a pasty state followed by pressing and heating under controlled temperature till shaping is finished.

(2033) U. S. 1,371,671 (1921). M. C. White and O. C. Duryea (American Briquet Machine Co.), *Art of Briquetting.* A block is formed of small metallic fragments by welding them into a solid mass by mild pressure; then the pressure is suddenly raised to a high degree by explosive force.

(2034) German 356,716 (1922). A. Gueret, *Method of Producing Alloys by Powder Metallurgy.* Method of producing alloys by powder metallurgy comprises simultaneously heating, pressing, and forging the shape to bring one of the constituents into a pasty or liquid state.

(2035) German 374,615 (1923). W. Guertler and M. Pirani, *Method of Producing Pressable Metallic Mixtures.* Pressable metallic mixtures composed of a powdered workable metal and a powdered not-workable metal are produced by pressing and heating the mixture to more than 500° C. (930° F.) till the mass is in a plastic state.

(2036) Australian 13,002/28 (1928). General Electric Co., *Improvements in and Relating to Hard Metal Compositions.* Hot-pressing of hard metal powder mixtures is claimed.

(2037) Brit. 330,577 (1930). L. W. Tools Co. Ltd., F. L. Ball and F. Moulton, *Bearings.* Metal powders are mixed with graphite, molded, and simultaneously pressed and heated, to cause fusion of the metal around the graphite particles.

(2038) German 497,558 (1930). Patent Treuhand Gesellschaft and M. Pirani, *Production of Hard Bodies of High Density.* A pressed and presintered body is compressed during heating in a press without lateral die parts.

(2039) German 513,445 (1930). O. Dienert, *Die for Hot-Pressing of Hard Metal Bodies.* Dies for hot pressing at 1300° C. (2370° F.) and 200 kg./cm^2. (2840 psi) consist of hard burned carbon.

(2040) U. S. 1,747,133 (1930). M. Pirani (General Electric Co.), *Preparing Dense Bodies of Material Such As Tungsten from Powdered Metal.* Method consists of sintering and resintering at high temperatures and simultaneously pressing the body while hot.

(2041) Austrian 124,079 (1931). Fried. Krupp, A. G., *Production of Hard Metal Bodies.* The formed body of WC or Mo_2C and a lower melting metal is pressed to plasticity to bring it into its finished form.

(2042) German 541,515 (1931). I. G. Farbenindustrie A. G., *Carbonyl Powder Pressings.* They are produced by simultaneously heating and pressing.

(2043) U. S. 1,793,757 (1931). W. H. Smith, *Hot Pressed Iron Alloys.* They are produced by combining finely divided metallic Fe with other metals under temperature and pressure without melting the Fe.

(2044) U. S. 1,822,939 (1931). H. H. Stout (Coalescence Products Co.), *Process for Treating Metals.* Shotted or broken-up cathode Cu is billetted and treated with cleansing gas at temperature below the melting point of Cu, then heated and pressed to a solid mass.

(2045) French 718,559 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Production of Articles of Hard Alloys.* The powder is pressed in a cold mold of electrically insulated material and simultaneously heated by an electric current.

(2046) Brit. 385,629 (1932). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Forming a Hard Metal Composition.* The method of forming a hard metal composition as described in Brit. 213,524 (No. 2655) and 251,929 (No. 2661) comprises pressing metal powders and simultaneously electrically heating them to sintering temperature in a cold mold of electrically insulating material in vacuum or inert gas, whereby a mass of greater density, having a length considerably greater than its transverse dimension, can be produced within shorter period of time.

(2047) Austrian 135,324 (1933). H. Fasching, *Method of Making Articles from Hard Alloys.* Hard alloys are hot pressed to a temperature just above the melting point of the carbides or nitrides and cooled in the same mold under pressure.

(2048) Brit. 394,193 (1933). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Hard Metal Composition for Dies or Cutting Tools.* Pieces of sintered Co-cemented W-carbides are hot pressed and thereby sintered.

(2049) U. S. 1,896,853 (1933). G. F. Taylor (General Electric Co.), *Welding Process.* Welding together of two dissimilar metal structures is accomplished by superimposing the metals in powder form in a non-conducting mold, applying pressure to the powdered metal and simultaneously passing a current through the powders.

(2050) U. S. 1,913,133 (1933). H. H. Stout (Copper Deoxidation Corp.), *Sintered Tin, Zinc, Aluminum, Brass and Bronze.* Sn, Zn, Al-powder particles are coated in a bath with Cu, hot-pressed and sintered at recrystallization temperature.

(2051) Austrian 137,185 (1934). A. Kratky, *Apparatus for the Production of Hard Metal Bodies.* It consists of a press with electrodes for heating the presintered and formed body, which are arranged around the die perpendicular to the movement of the ram.

(2052) U. S. 1,951,133 (1934). J. H. L. De Bats, *Refractory Carbide Bodies.* The refractory carbide is ground to a particle size below 100 mesh, compressed into a briquette, heated to a temperature greater than the shrinkage temperature, followed by repressing the hot mass in a mold.

(2053) U. S. 1,965,670 (1934). H. A. Schauer, *Apparatus for Coining Metal Objects.* Metal chips are reduced to a plastic state in a heated crucible directly connected with a forming press, to avoid major machining operations.

(2054) Brit. 431,509 (1935). British-Thomson-Houston Co. Ltd., *Manufacturing Mold for Cemented Carbides.* A heavy W and Mo-tube supports a hollow C-tube which serves as die for hot-pressing. The metal tube is heated by passing through it an electric current of high amperage.

(2055) Brit. 434,830 (1935). A. Kratky, *Method of Making Hard Cemented Bodies for Tools.* It comprises heating a shaped block of carbides with or without additions such as nitrides, metals, etc., above the die into which the material is then forced under pressure.

(2056) U. S. 1,993,774 (1935). J. H. L. De Bats, *Centrifugal Casting of Carbides.* The carbides are directly heated to 3600° C. (6540° F.) while positioned in a die which rotates at such speeds that centrifugal compacting of the carbide material occurs.

(2057) French 801,270 (1936). Ecla-Verfahren A. G., *Production of Bearing Metal.* Small pieces of Fe wire, whose length is greater than the diameter, are mixed with Cu and alcohol, pressed, and molded at 800° C. (1470° F.) by heating with high-frequency current.

(2058) French 805,985 (1936). A. Kratky, *Pressing of Hard Carbide Alloys. Cf.:* U. S. 2,076,952 (No. 2062).

(2059) Swedish 88,111 (1936). A. Kratky, *Production of Formed Pieces of Hard Metal Carbides. Cf.:* Austrian 137,185 (No. 2051).

(2060) Swiss 183,504 (1936). A. Kratky, *Production of Tools of Sintered Hard Carbides. Cf.:* Austrian 137,185 (No. 2051).

(2061) Austrian 150,931 (1937). A. Kratky, *Apparatus for Producing Hard Powder Compacts.* An inductively heated centrifugal apparatus for producing compact hard carbides or nitrides or hard alloys from powdered starting materials is disclosed.

(2062) U. S. 2,076,952 (1937). A. Kratky, *Hard Metal Alloys Such as Those of Hard Carbides and their Manufacture.* Alloys are obtained by hot-pressing carbide and Fe matrix into thin plates and pressing these together one at a time.

(2063) U. S. 2,089,030 (1937). A. Kratky, *Hard Bodies such as Cutting Tools from Powdered Refractory Material.* Powdered carbides are pressed, heated between two electrodes, thus functioning as a resistance, and driven onto a matrix by a quick blow.

(2064) German 655,932 (1938). Heraeus Vacuumschmelze A. G. and W. Rohn, *Hot-Pressing of Hard Metal Tools.* Method of producing tools of carbides, borides,

silicides, etc. of refractory metals combined with lower melting metals comprises pressing the briquette of the refractory metals at a temperature above the melting point of the lower melting metal and with such a high pressure that the surplus of the lower melting metal is pressed out.

(2065) Swiss 194,805 (1938). A. Kratky, *Method for the Production of Formed Bodies.* Briquettes of metal carbide powders are heated up to the softening point, and pressed into the die by the stroke of the ram, which itself does not enter the die.

(2066) Swiss 196,713 (1938). A. Kratky, *Production of Carbides, Nitrides or Hard Metals for Tools.* The metal powder is put in a round vessel, heated by induction, and compressed by the rotation of the vessel.

(2067) Brit. 506,486 (1939). N.V. Wallramit Handel Maatschappij, *Apparatus for Obtaining Coherent Masses from Hard Metal by Heat and Pressure Treatment.* The apparatus consists of a conveying device with clamps, molds of an electrically conductive material that contain the metal powder to be treated, and means for supplying electrical current to the molds. Material is first heated, then pressed, cooled, and removed from the molds.

(2068) Brit. 506,728 (1939). Metal Carbides Corp., *Manufacture of Hard Metal Carbide Articles by Hot-Pressing. Cf.:* U.S. 2,167,544 (No. 2071).

(2069) French 847,488 (1939). Metal Carbides Corp., *Production of Hard Metal Bodies.* WC powder is pressed in a mold and simultaneously heated in an induction furnace to produce a dense body.

(2070) U. S. 2,162,701 (1939). G. J. Comstock (Handy & Harman), *Manufacture of Articles from Powdered Metals.* Mosaics are produced from powdered metals by forming a plurality of sintered bodies of different compositions by simultaneous application of heat and pressure, the bodies being easily workable. The bodies are divided into pieces, assembled and hot-pressed.

(2071) U. S. 2,167,544 (1939). J. H. L. De Bats and J. A. Ritz (Metal Carbides Corp.), *Hard Metal Articles.* The method of manufacture of hard metal articles involves pressing the powdered W- or Mo-carbide material in a mold progressively in a lengthwise direction, while simultaneously locally heating the body, also progressively in a lengthwise direction.

(2072) Brit. 523,318 (1940). Deutsche Gold- & Silberscheideanstalt A. G., *Improvement in or Relating to the Production of Metallic Bodies.* Ag-Mo, Ag-graphite, Ag-Ni alloys are hot-pressed; rolling and drawing with intermediate annealings is resorted to in the production of wires.

(2073) Brit. 527,064 (1940). C. Eisen and J. J. Haesler, *Hot Pressing of Hard Metal Carbide Alloys.* Preparation of refractory metal alloys comprises heating a mixture of at least 50% powdered metal carbides and a powdered auxiliary metal to below the melting point of the carbides, then gradually applying an increasing continuous pressure to the alloy accompanied by vibration.

(2074) Brit. 530,995 (1940). W. D. Jones, *Metallic Articles.* A brass or a bronze powder or a mixture of them is subjected to pressure at an elevated temperature between 650 and 800° C. (1200 and 1470° F.). The powders are subjected to a preliminary cold pressing at 5 tsi.

(2075) Brit. 530,996 (1940). W. D. Jones, *Metal Articles.* An Al alloy powder containing a small proportion of one or more elements such as Mn, Mg, Sb, Ti is subjected to a pressure at 400-600° C. (750-1110° F.). CaH_2, TiH_4, ZrH_4, or an alkali metal hydride can be added to the powder.

(2076) German 685,115 (1940). Meutsch, Voigtländer & Co., *Hot-Pressing Compacts.* An apparatus for hot-pressing compacts in a continuous operation is disclosed.

(2077) U. S. 2,193,413 (1940). P. Wright, C. Eisen and J. J. Haesler, *Process of Producing Hard Metal Carbide Alloys.* Refractory metal carbides are produced by heating them with auxiliary metal to a temperature above the melting point of the latter, and gradually applying increasing pressure, accompanied by vibration, and maintaining both during cooling.

(2078) U. S. 2,195,297 (1940). E. W. Engle (Carboloy Co.), *Method and Apparatus For Making Hot-Pressed Hard Metal Composition.* Hot-pressing of cemented hard

metal carbides is performed in a mold surrounded by a furnace, whereby electric current may be passed through the mold.

(2079) U. S. 2,211,984 (1940). A. Paterson, *Method of Producing Billets from Steel Scrap.* Scrap, reduced to the form of ingot-like bale, is briquetted by compressing at ambient temperature to increase the density. Hot-rolling may complete the fabrication.

(2080) Brit. 540,105 (1941). M. Stern, *Briquetting Scrap of Light Metal.* The scrap is compressed and heated to 250-500° C. (480-930° F.), to yield shaped bodies having a density equal to the density of the original metal; the temperature must lie beneath that at which oxidation of the light metal occurs at a damaging rate.

(2081) French 861,276 (1941). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Production of Hard Metal Alloys.* It is accomplished with pressure and simultaneous indirect and direct heating, the latter being regulated electrically to compensate for the loss in heat during the operation.

(2082) U. S. 2,253,385 (1941). W. E. Mahin (Westinghouse Electric & Mfg. Co.), *Tool Steels.* Compositions suitable for hot-pressing dies and permanent molding operations are claimed.

(2083) German 719,730 (1942). Deutsche Gold- & Silberscheideanstalt A. G., *Manufacture of Articles from Powdered Metals.* Mosaics are produced from powdered metals according to process of U. S. 2,162,701 (No. 2070).

(2084) German 728,165 (1942). F. Sattler, *Production of Graphite Containing Metal Bodies.* A mixture of graphite and metals or alloys is pressed in molds and heated for sintering into solid bodies, which are then cooled while maintaining the pressure.

(2085) U. S. 2,287,951 (1942). H. Tormyn (General Motors Corp.), *Manufacture of Metal Articles such as Rings, Bushings or Brake Drums in Finished Shape.* Metal fragments such as steel or cast Fe chips are placed in a mold and formed under heavy pressure into a solid piece, then hot-pressed.

(2086) U. S. 2,302,980 (1942). M. Stern, *Process for Briquetting Aluminum and Aluminum Alloy Scrap.* It comprises heating the de-oiled and oxide-covered scrap during compression to at least 300° C. (570° F.), to soften the body of the metal particles encased in the oxide skins, and to dissociate the skins from the particles, in order to form a homogeneously bonded body of the metal particles with the oxide skins.

(2087) German 736,962 (1943). Deutsche Edelstahlwerke A. G. and C. Ballhausen, *Device for Hot-Pressing of Hard Metal.* It consists of a mold and punches of graphite and a high frequency induction coil having only one winding which surrounds the mold very closely.

(2088) German 738,536 (1943). Deutsche Edelstahlwerke A. G. and F. Krall, *Hot Pressing or Extrusion of Bodies Made of Metals Having Different Melting Points.* Metal powders containing approx. 80% of one or more of the metals W, Mo, Ta and rest consisting of at least one low-melting metal such as Ag, Cu, Au, Al, Pb, Sn, Zn, Fe, Co, Ni, Fe, Cr, are compressed at temperatures below the melting point of the lowest melting member; then pressure is applied in the order of at least twice the former pressure at a temperature of 70-90% of the melting point of the lowest melting component, and the compact is either retained in the hot-press die or extruded.

(2089) U. S. 2,332,277 (1943). M. Stern, *Briquetting Magnesium and Magnesium Alloy Scrap.* Fine scrap such as turnings are cleaned and pressed without binders at temperatures between 250 and 500° C. (480-930° F.) to produce a compact body.

(2090) U. S. 2,343,978 (1944). W. D. Jones, *Manufacture of Non-Porous Articles.* A process of compressing and simultaneously heat treating brass or bronze powders to form non-porous articles having high tensile strength and elongation is claimed.

(2091) U. S. 2,355,954 (1944). G. D. Cremer (Hardy Metallurgical Co.), *Powder Metallurgy.* A powder compact is heated by electric current while it is compressed between electrodes, thereby heating the points of contact between the particles in the compact to a temperature near the melting point; this is accomplished by passing through the compact an electric current of such amperage that the temperature is

attained instantaneously at the contact points while the balance of the particles remains relatively cold.

(2092) U. S. 2,362,701 (1944). R. P. Koehring (General Motors Corp.), *Hot Pressing and Furnace Assembly for Making Metal Parts.* A powder portion is heated and agglomerated and then transferred into a hot-press die assembly while hot to form porous or dense bodies under controlled atmospheric conditions.

(2093) Brit. 573,113 (1945). A. Johnson & Co. Ltd. and E. A. Bano, *Alloys.* W-Ag, Cu-Ag, or Al-Cu alloys are produced by mixing the metal powders in a ball mill for a prolonged period, and then heating and pressing simultaneously; the alloy is cooled while pressure is maintained.

(2094) U. S. 2,372,605 (1945). W. F. Ross (Fellows Gear Shaper Co. and Jones & Lamson Machine Co.), *Method and Apparatus for Making Solid Objects from Metal Powder.* It involves hot-pressing by direct current, with control of the temperature, the amount and timing of heat input during the pressing; a shock or impact loading in conjunction with a constant loading takes place during pressing.

(2095) U. S. 2,393,130 (1946). H. A. Toulmin, Jr. (H-P-M Development Corp.), *Powder Metallurgy.* A method for hot-pressing metal powders comprises preheating them, followed by pressing into a compact; the compacting chamber includes means for heating the metal to sinter or alloy into a workpiece.

(2096) Brit. 594,860 (1947). The AC Sphinx Sparking Plug Co. Ltd., D. H. Corbin and O. W. Dokkolsen, *Molding Machine for Plastic Materials.* An automatic press for hot-pressing powders for spark plugs is disclosed.

(2097) U. S. 2,431,095 (1947). W. R. Tucker (H-P-M Development Corp.), *Apparatus for Hot-Pressing Powdered Metal.* A hot-press for molding of metal powders with plastics has a heating chamber of insulating material with an induction coil in alignment with the die cavity.

(2098) French 936,494 (1948). Metallwerk Plansee G.m.b.H., *Manufacture of Press Tools from Hard Metal.* Press tools with complicated design are made by hot-pressing carbide powder with a graphite punch, which has been engraved with the design.

(2099) Brit. 623,854 (1949). Charles Hardy, Inc., *Powder Metallurgy.* Compacts of Al, Cu or bronze are instantaneously sintered under pressure of 7 tsi by exposing them to a current of the order of 2,000,000 amps./in.^{2} for 1 or 2 cycles of a 60-cycle current. W electrodes with graphite coating are used, and the die walls are lubricated with a mixture of Al flake powder and stearic acid.

(2100) U. S. 2,473,476 (1949). J. W. Knowlton (Norton Co.), *Method and Mold for Making Boron Carbide Articles.* Method is applicable to molding of boron carbide articles from powders and comprises filling the cavities of a graphite mold which are separated by graphite plates, and simultaneously heating and pressing the material therein. The pressure is exerted edgewise of the resulting flat plates.

B. Pressure Sintering

(2101) Brit. 113,835 (1918). M. J. Insull, *Process and Apparatus for Sintering Tungsten Ingots.* The ingot is sintered while subjected to a continuous longitudinal compressive stress between the electrodes, and held in a horizontal plane.

(2102) U. S. 1,267,801 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Process for Welding Tungsten Ingots.* Sintering of W ingots comprises subjecting the whole ingot of compressed W particles to a longitudinal compressive stress and then heating the ingot by passing an electric current.

(2103) French 577,196 (1924). S. A. Lumière, *Method of Making Tungsten or Molybdenum Ductile.* The metal body is heated under pressure almost to its melting point.

(2104) Brit. 231,242 (1925). C. H. Fisher, *Manufacture of Bodies from Refractory Metals.* Metal powder is compressed in neutral atmosphere to form a continuous length; the body is heated and sintered along one portion of its path and simultaneously compressed to the desired shape.

(2105) Czech. 42.241 (1933). Allgemeine Elektrizitäts Gesellschaft, *Hard Metal for Cutting Tools.* A mixture of WC and Co is pressure-sintered at a temperature below the melting point of the auxiliary metal.

(2106) U. S. 1,895,354 (1933). G. F. Taylor, (General Electric Co.), *Resintering Hard Metal Composition.* A quartz tube with a Mo plunger is used for applying slight pressure to W powder mixed with Co; an electric current is applied for resintering the mixture.

(2107) French 793,020 (1935). M. Goldenzweig, *Method of Sintering Carbides Under Pressure.* The powdered mixture of carbides and binders is introduced into a C-mold and heated in a furnace to 1600-2000° C. (2910-3630° F.) under high vacuum. When the binder is fused, a pressure of 20-100 atm. is exerted.

(2108) Brit. 497,871 (1938). W. D. Jones and E. J. Groom, *Forming Metal Masses or Articles From Powders.* Fe, C and other powders are partially sintered under pressure and in the presence of a small proportion of an impurity which has a bonding action, by heating to a temperature below that of complete fusion of the alloy to cause agglomeration of the particles into the article.

(2109) German 666,924 (1938). Heraeus-Vacuumschmelze A. G. and W. Rohn, *Hard Metals.* Pressure-sintering of fine grained hard metals is performed with carbides, produced from the oxides of metals whose carbides crystallize in different systems of crystallization.

(2110) German 677,231 (1939). Hardy Metallurgical Co., *Improvements in the Production of Composite Metal Articles.* They consist of compressing and heating a mass of plated metal powder having cores of low-melting point metal and platings of higher-melting point metal, like Cu-Pb. Coherent mass is fastened to metal backing by pressing together, and then sintering under slight static pressure as produced by dead weights or spring tension.

(2111) U. S. 2,149,596 (1939). R. W. Dayton and H. W. Gillett (The Bunting Brass & Bronze Co.), *Method for Producing Metallic Material.* Reclaiming of scrap machinings of an alloy such as bronze having high electrical conductivity comprises passing an electrical current through the machinings of a current density sufficient to cause a strong pinch effect, and applying a minimum pressure to balance the pinch effect, and discontinuing the passage of the current after a predetermined interval.

(2112) U. S. 2,219,095 (1940). P. Schüttler, *Method for Producing Piston Rings.* Rings for light metal pistons of internal combustion engines are produced by sintering under pressure a mixture of metal powders consisting of 10-30% Co, 2-5% Ni, 1-4% Mg, 2-5% Cr, remainder Al.

(2113) German 705,886 (1941). P. Schüttler, *Method for Producing Piston Rings. Cf.:* U. S. 2,219,095 (No. 2112).

(2114) U. S. 2,228,916 (1941). L. Simons, *Method of Making an Alloy.* A refractory material consisting of a metal carbide and a metal of a melting point below 2000° C. (3630° F.) is sintered under pressure.

(2115) U. S. 2,258,431 (1941). S. K. Wellman (S. K. Wellman Co.), *Heat Treating Press and Furnace.* The housing has a central elevated table and fluid pressure means, constructed to apply downward pressure to the top wall of the housing cover, to effect compression of plate-like articles.

(2116) U. S. 2,341,860 (1944). E. E. Ellis (S. K. Wellman Co.), *Making Chambered Metallic Fittings Such as Valve Bodies.* In the briquetting of reduced Fe powder into chambered metallic parts, two sections are pressed at pressures between 44 and 66 tsi, which are joined under 35 psi side pressure during sintering.

(2117) U. S. 2,349,080 (1944). A. D. Deck (Wesco Waterpaints Inc.), *Apparatus for Compacting Powdered Solid Materials Containing Occluded Or Entrapped Air or Gas.* Compressing of metal powders occurs between two endless belts carried over pulleys; the belts are porous to permit passage of air or gas while passing through a furnace.

(2118) German 750,932 (1945). C. Ballhausen and W. Telorac, *Apparatus for Producing Reaction between Powdered Materials.* Metal oxides or metal-carbon mixtures are passed through a pair of graphite rollers with corrugated surfaces

with the corrugations on one roller being smaller than on the other, thus producing a gap. The material (*e.g.* W-carbide) is heated during rolling by passage of an electric current.

(2119) U. S. 2,387,013 (1945). I. C. Fuller, *Turncock.* A turncock may be produced by sintering metal powders under pressure.

(2120) Brit. 624,889 (1949). The S. K. Wellman Co., *Separator Members for Powder Metallurgical Processes.* A series of friction plates are stacked and pressure-sintered simultaneously, with separator members, required to keep each plate separate. An alloy of 25-35% Cr, 3-5% Ni, 1-1.5% Mo, 0.1-0.2% C, balance Fe for the separator members has been found fit.

5. EXTRUSION OF COMPACTS
(Refractory Metals, Lower Melting Metals)

(2121) U. S. 1,594,347 (1926). H. E. Bakken (American Magnesium Corp.), *Working Magnesium.* Pure sublimed Mg in crystalline form whose particles are discrete is worked into wire by heating under pressure and extruding.

(2122) Swiss 169,762 (1934). H. Esser, *Production of Iron Bodies from Iron Sponge.* Powdered Fe sponge, with or without other metallic additions, is pressed and formed in an extrusion press at 700-1300° C. (1290-2370° F.).

(2123) Austrian 140,527 (1935). A. Kratky, *Apparatus for Extrusion of Powders.* A continuous apparatus for making pipes from metal powders comprises extrusion and sintering.

(2124) U. S. 2,018,300 (1935). H. Esser, *Method of Producing Industrial Iron by Means of Iron Sponge.* It consists of pressing a sponge containing C and Fe into a rough form and subjecting the pressed material in an extrusion press to a pressure which causes a considerable flow of the particles.

(2125) U. S. 2,097,502 (1937). G. T. Southgate (Union Carbide & Carbon Corp.), *Producing Rods of Comminuted Metal Powders.* The powder is continuously fed into a die so that predetermined quantities are successively impacted by a plunger and compacted and advanced by the frictional resistance of the die, and extruded in form of a rod.

(2126) Brit. 484,996 (1938). N. V. Molybdenum Co. and L. N. Reddie, *Extrusion of Hot-Pressed Alloys.* A mixture of a metal powder of a high melting point (*e.g.* W, Mo, Ta, Si, C) and one of a low melting point (*e.g.* Cu, Ag, Au, Al, Pb, Sn) is hot-pressed below the melting temperature of the low-melting point metal and extruded at high pressure.

(2127) French 823,238 (1938). N. V. Molybdenum Co., *Extrusion of Hot-Pressed Alloys. Cf.:* Brit. 484,996 (No. 2126).

(2128) U. S. 2,123,416 (1938). A. B. Graham (International Nickel Co.), *Method of Extruding Metals and Alloys.* A method of extruding metals and alloys by coalescence of powder particles is claimed.

(2129) U. S. 2,148,040 (1939). P. Schwarzkopf, *Method of Manufacturing Composite Materials and Shaped Bodies.* Extrusion of carbides and softer metallic binder is claimed.

(2130) Austrian 159,190 (1940). Deutsche Edelstahlwerke A. G., *Production of Briquettes Consisting of Two Different Metals.* A sintered mixture of W-Cu or W-Ag powders is extruded at a temperature somewhat below the melting point of the lower melting metal.

(2131) U. S. 2,205,865 (1940). P. Schwarzkopf (American Electro Metal Corp.), *Method of Manufacturing Alloys, in Particular, Steel Alloys.* An extrusion press and a method of extruding alloys consisting of at least two elements, densified prior to extruding, are disclosed.

(2132) U. S. 2,225,424 (1940). P. Schwarzkopf (American Electro Metal Corp.), *Manufacture of Alloys, in Particular, Steel Alloys.* Solid and dense bodies are produced by hot-extrusion.

(2133) German 717,790 (1942). F. P. C. Benoit, *Extrusion Apparatus for Powders Such as Powdered Metals.* An extrusion apparatus having helical blades and a sensitive control for the heating gas is disclosed.

(2134) U. S. 2,271,960 (1942). G. F. Taylor (Carboloy, Inc.), *Extrusion Process for Tungsten Carbide Rods.* The process involves the mixing of the ingredients to be extruded, such as WC and starch, pressing them into shape, removing the gases, and extruding the product.

(2135) U. S. 2,290,734 (1942). H. A. Brassert (Minerals & Metals Corp.), *Manufacture of Metal Products.* Fe-ore is reduced and heated in protective atmosphere and extruded in a container to obtain a solid homogeneous structure.

(2136) French 880,632 (1943). Patentverwertungs G.m.b.H., Hermes, *Casing for Electrical Cables.* The mantle of the cable is formed by extrusion in a press which is filled with small pieces or particles of Al and heated.

(2137) French 884,721 (1943). Metallgesellschaft A. G., *Production of Sintered Pieces of Great Length.* A metal tube is filled with metal powder, extruded and annealed whereby the powder particles form bonds between themselves and with the metal tube.

(2138) German 734,049 (1943). W. Dawihl (Fried. Krupp, A. G.), *Extrusion Process for Hard Alloy Shapes Suitable for Sintering.* The feed of the extrusion press is stopped at intervals to evacuate the air from a section of the extruded hard metal paste within the press, which then is set under gas pressure, whereupon that particular length is pressed out, to produce a section subjected uniformly to the effects of the vacuum and the subsequent gas pressure.

(2139) German 742,850 (1943). K. Schmidt G.m.b.H. and R. Sterner-Rainer, *Production of Bearing Metal.* Al or Al-alloy particles are pre-pressed, heated to sintering temperature and then worked in an extrusion press.

(2140) U. S. 2,316,665 (1943). H. A. Brassert and S. P. Kinney (Minerals & Metals Corp.), *Production of Iron or Steel.* The method consists of compressing the powdered product of a reducing operation while hot, then raising the temperature to fuse the gangue and squeeze the mass, to press out the slag, until its content in the extruded mass is reduced to the desired degree.

(2141) U. S. 2,358,667 (1944). M. Stern, *Method for the Production of Shaped Articles Such As Tubes, Rods, Profiles from Magnesium and Magnesium Alloy Scrap.* The method consists of compressing the scrap into sufficiently coherent bodies to exclude self-ignition, heating and simultaneously extruding the scrap into final article.

(2142) U. S. 2,378,539 (1945). W. Dawihl, *Process of Making Shaped Bodies Capable of Being Sintered.* Hard metal alloys are pressed in three successive stages under vacuum and extruded.

(2143) Swedish 110,300 (1947). Finspongs Metallverks A. B. and S. G. Holmström, *Production of Sintered Alloys.* Metal powder, *e.g.* W-Cu, or W-Mo-Cu, or W-Ag, is mixed and shaped in extrusion presses.

(2144) U. S. 2,414,029 (1947). H. B. Duncan (Carboloy Co.), *Extrusion Apparatus and Process.* Apparatus for extruding mixed powdered cemented carbide ingredients is disclosed.

(2145) Brit. 597,638 (1948). British Thomson-Houston Co. Ltd., *Apparatus for Extruding Powdered Material.* A length of plastic cemented carbide material for extruding is made by compacting a mixture of WC, Co and starch in a ring-shaped die, provided with a perforated screw cap for impregnating the mixture with a glycerine solution.

(2146). U. S. 2,437,625 (1948). G. F. Taylor (Carboloy Co.), *Process and Die for Extruding Tubular Products.* The process of making thin-walled cemented carbide tubes comprises extruding a plastic mixture of ingredients in form of a tube, out of contact with a refractory support, drying, and sintering the tube to form a hard, dense mass.

(2147) Brit. 614,181 (1949). Philips Lamps Ltd., *Manufacturing Magnetic Cores.* A ferrite-forming mixture of oxides with organic binder is formed in an extrusion press, and then sintered to form the ferrite.

6. METAL WORKING OF COMPACTS

A. Cold or Hot Repressing and Sizing

(2148) Brit. 231,292 (1925). C. H. Fischer, *Hot Forming Tungsten and Molybdenum from Powder.* W and Mo powders are compressed and heated in neutral atmosphere under such conditions that a ductile body is obtained; the compressed material while being moved forward is heated to sintering temperature and simultaneously sized to the desired diameter.

(2149) U. S. 1,531,666 (1925). C. A. Laise, *Metal Body of High Density.* It is obtained by compacting metal powders with a small quantity of a volatile substance to the desired form, volatilizing the substance at high temperature and compacting the article further by repressing at a lower temperature by an impact tumbling action.

(2150) Brit. 280,497 (1928). Bound Brook Oil-Less Bearing Co. and C. Claus, *Apparatus for Sizing Metal Bushes for Bearings.* It permits the finishing of annular bearings of porous compressed compositions and of preforms oversize relative to their final dimensions.

(2151) U. S. 1,722,787 (1929). C. Claus (Bound Brook Oil-Less Bearing Co.), *Method of a Machine for Sizing Compacted Metal Members.* Finishing a blank composition metal bushing of preformed oversize to its final dimensions is accomplished by subjecting the wall to a radial compression enlarging the inside diameter, while its exterior is held against expansion, and compressing the blank endwise to compact the material to final size and length.

(2152) U. S. 2,168,227 (1939). J. A. Lignian (General Motors Corp.), *Sizing Porous Metal Bearings.* Sizing and seating a flanged bearing in a recess comprises assembling the bearing on a sizing mandrel, then introducing the bearing in a receiving recess and applying peripheral pressure on a small area to deform the bearing radially inwardly around the mandrel at the flanged end.

(2153) U. S. 2,168,300; 2,168,301 (1939). J. C. Lemming (General Motors Corp.), *Sizing Porous Metal Bearings.* By passing the bearing on a sizing mandrel through a succession of sizing dies of progressively decreasing diameter, the bearing is compressed radially inwardly to the diameter of the mandrel.

(2154) U. S. 2,226,002 (1940). A. J. Langhammer (Chrysler Corp.), *Sizing and Finishing Projectiles.* An apparatus is adapted for the sizing and finishing of projectiles, such as porous bullets having a lubricant absorbing capacity, so that the surfaces of the projectiles are brought to a smoothed and polished condition by the combined rotative and slipping action of the die members.

(2155) German 723,387 (1942). H. Vogt, *Pressing of Hard Metal Bodies.* The powder is prepressed so that the body has a uniform density, and then it is repressed between rubber plates.

(2156) U. S. 2,319,373 (1943). H. Tormyn (General Motors Corp.), *Ferrous Metal Articles Such as Brake Drums.* A pressed and heated semi-finished article is shaped to desired final form by repressing it in dies which come in contact with the metal both axially and laterally during the entire pressing operation. The dies have segmental jaws which move radially inward during the pressing operation and permit any slight excess material to flow outward between the segmental jaws.

(2157) U. S. 2,393,718 (1946). O. Stenson and R. A. Vinson (Western Electric Co.), *Material Forming Apparatus.* An apparatus for hot sizing W leads on the stem of a vacuum tube with two sets of jaws is disclosed.

(2158) **Brit. 594,918** (1947). The British Piston Ring Co. Ltd. and J. A. Judd, *Manufacture of Piston Rings.* Sintered ferrous piston rings are hot-coined by cutting oversize rings to length, and cold pressing them in a die, followed by heating in the die to 600-700° C. (1110-1290° F.) for 20-30 min. in a non-oxidizing atmosphere.

(2159) **Austrian 162,869** (1949). Gebr. Böhler A. G., *Production of Alnico Magnets.* The sintered bodies are hot-coined.

B. Cold and Hot Working (Hammering, Forging, Swaging, Rolling, Drawing)

(2160) **U. S. 971,385** (1910). I. Kitsee, *Production of Metallic Filament.* An ingot is produced from a metal-phosphide converted into a porous metallic mass, which is subjected simultaneously to high temperature and mechanical stress, and drawn into wire.

(2161) **U. S. 1,273,506** (1918). A. Lederer (Westinghouse Lamp Co.), *Manufacture of Wires from Refractory Metal Bodies.* It comprises covering the bodies with a non-metallic volatile substance such as S or Se, drawing the covered body, and removing the substance.

(2162) **Austrian 98,149** (1924). Deutsche Glühfadenfabrik Rich. Kurtz and P. Schwarzkopf, *Production of Plates, Strips or Sheets of Tungsten or Molybdenum.* A sintered or fused bar is mechanically worked, so that the expansion in the transverse direction is larger than the elongation in the longitudinal direction of the bar.

(2163) **Brit. 221,295** (1924). E. C. R. Marks, Deutsche Glühfadenfabrik Rich. Kurtz, and P. Schwarzkopf, *Producing Plates from Refractory Metals.* Manufacturing plates or strips from bars of W or Mo by rolling the bar in transverse direction, *viz:* at right angles to the longitudinal axis thereof.

(2164) **Austrian 100,982** (1925). J. Winsch and C. H. Fischer, *Method of Producing Filaments of Tungsten.* Sintered bars of 8 mm. diameter are drawn at 900° C. (1650° F.) without previous working.

(2165) **Brit. 246,406** (1926). Treuhand Gesellschaft für Elektrische Glühlampen and General Electric Co., *Preparation of Tungsten Wires.* The wires are reduced by drawing to 0.05 mm. and subjected for a minute or less to the action of an extremely powerful and rapid etching agent.

(2166) **U. S. 1,882,987** (1932). W. Schubardt and L. Schlecht (I. G. Farbenindustrie A.G.), *Process of Making Metal Articles.* Fe-articles are produced by subjecting a mixture of scrap Fe and Fe-powder prepared by thermal decomposition of Fe-carbonyl to a heat-treatment at 600° C. (1100° F.) and rolling.

(2167) **Austrian 138,748** (1934). P. Schwarzkopf, *Production of Sintered Hard Alloys.* The pressings produced of practically chemically pure metal powders are sintered several times in vacuum or a reducing atmosphere and are hot worked between the sintering periods to produce a nonporous body.

(2168) **German 601,551** (1934). Siemens-Schuckertwerke A. G., *Manufacture of Tools With Very Hard and Dense Surfaces.* Sintered material is worked mechanically by hammering and drawing, then finally formed and carburized.

(2169) **German 635,644** (1936). Vereinigte Edelstahl A. G., *Production of Sintered Alloys.* Nonporous bodies are obtained by heating the pressed powders alternately *in vacuo* and reducing atmosphere, and by mechanically hot working them between the heating periods.

(2170) **U. S. 2,091,903** (1937). H. T. Baggett and G. W. Woods (Hughes Tool Co.), *Production of Tungsten Carbide Sheets.* Process of forming thin cemented sheets of WC comprises bringing the powdered ingredients to a molten condition in a crucible above a set of compression rolls, which are then used to eliminate the gases and to roll out the material to sheets.

(2171) **Brit. 521,012** (1940). General Electric Co., Ltd., *Working of Sintered Alloys.* Sintered W-Ni-Cu alloys with a density of 15 are hot-worked by forging or rolling.

(2172) **German 693,032** (1940). Deutsche Eisenwerke A. G., *Manufacture of Molds.* Molds for centrifugal casting of tubes are made from sintered plates which immediately after sintering are hot rolled or bent into shape.

(2173) **U. S. 2,206,395** (1940). S. E. Gertler and H. I. Stein, *Process for Obtaining Pure Chromium, Titanium and Certain Other Metals and Alloys Thereof.* The powder is compressed and sintered in an air-tight envelope, cooled, reheated in another air-tight envelope, worked hot, cooled, and reworked cold.

(2174) **U. S. 2,252,697** (1941). H. A. Brassert (Minerals & Metals Corp.), *Manufacture of Metal Products.* Metal objects, such as bars, tubes and rods, are produced by pressing and working at elevated temperature, without melting, reduced sponge Fe particles or other metal.

(2175) **French 912,503** (1944). Mannesmannröhren-Werke, *Iron Powder Working.* Fe-powder produced by atomizing molten cast Fe according to French 900,422 (No. 895) is pressed, sintered and rolled into strips. An alloy powder may be incorporated during rolling.

(2176) **U. S. 2,383,766** (1945). H. A. Brassert (H. A. Brassert & Co.), *Manufacture of Metal Products.* An apparatus for low-temperature reduction of Fe-oxide provides for subsequent rolling of the hot metal into briquettes, reheating and final shaping and deforming.

(2177) **Swiss 248,874** (1948). M. Gloor and F. Koref, *Production of Tungsten Bodies of High Density.* A presintered pressed body with a hole is highly sintered and hot worked, to produce an elongation in the direction of the axis of the hole.

7. SUBSEQUENT TREATMENT OF PRODUCTS

A. Heat Treatment (Annealing, Hardening, Quenching, Purifying)

(2178) **U. S. 1,280,704** (1918). C. T. Fuller (General Electric Co.), *Treatment of Tungsten Filaments.* The mechanical properties of drawn W wires are improved by heating them to red heat in an oxidizing atmosphere.

(2179) **German 397,641** (1924). Siemens & Halske A. G., *Method of Purifying Tantalum.* Method of purifying tantalum comprises heating it under very high vacuum at a temperature below the melting point.

(2180) **German 399,896** (1924). General Electric Co. Ltd., *Aftertreatment in the Production of Tungsten Wires.* The wire is annealed, then stretched, then heated very quickly to white heat.

(2181) **Brit. 324,028** (1930). I. G. Farbenindustrie A. G., *Improvements in the Manufacture and Production of Shaped Articles of Metallic Oxides.* Shaped articles produced by sintering metal powders prepared by thermal decomposition of the carbonyls are subjected to an oxidation treatment.

(2182) **Brit. 390,426** (1933). British Thomson-Houston Co. Ltd. and W. P. Sykes, *Improvement in or Relating to Metal Alloys.* A sintered alloy consisting of 40-60% Fe, 20-30% Co, the remainder a metal having the characteristics of W, is age-hardened.

(2183) **Brit. 429,828** (1935). Comp. Lorraine De Charbons Pour L'Electricité (British Thomson-Houston Co.), *Tempering of Hard Alloys for Dies, Tools, and Draw Plates.* Carbides, nitrides, borides, silicides of W, Mo, Ti, Ta, Zr, Cb, V, and Fe, Co, Ni are mixed, sintered; then tempered at 1100° C. (2000° F.), retempered at 600° C. (1100° F.).

(2184) Brit. 477,181 (1937). W. H. Hatfield and B. Holdon, *Quenching of Sintered Hard Alloys.* Sintered cemented carbides of W, Ta, Ti, Mo, Cr and V, cemented with Ni, Co, Fe, are quenched from the sintering temperature (1400-1700° C.; 2550-3090° F.) to 200° C. (390° F.).

(2185) U. S. 2,187,589 (1940). F. V. Lenel (General Motors Corp.), *Porous Iron Article.* It is produced by briquetting powdered iron under high pressure to a slightly smaller than desired, sintering it to form a strong porous article, and then subjecting it to steam between 530-800° C. (1000-1500° F.) to oxidize the surface and to cause the article to increase in size, as well as to render it corrosion resistant and wear resistant at the exposed surfaces.

(2186) U. S. 2,215,645 (1940). C. V. Iredell and T. J. Hankins (Westinghouse Electric & Mfg. Co.), *Treating Tungsten Wire.* The quality is improved by heating the wire in H_2.

(2187) French 861,303 (1941). N. V. Philips' Gloeilampenfabrieken, *Production of Annealed Hard Metal Alloys.* 94% WC with 6% Co is hot pressed and the body is then annealed in an atmosphere of 85% N_2 and 15% H_2 at 1450° C. (2640° F.). Using atmospheric pressure, the density is 14.5; using 50 atm. pressure the density is 14.85.

(2188) German 709,952 (1941). Heraeus Vacuumschmelze A. G., *Treatment of Sintered Carbides for Tools.* The hard metal contains a precipitation-hardenable binder alloy of Co with 10-20% Cr, 5-15% Mo, 0-15% Fe, 0.6-2.5% Ti. The sintered article is quenched from over 1000° C. (1830° F.) at which Co is liquid, then reheated to 500-700° C. (930-1290° F.).

(2189) German 741,535 (1943). H. Vogt, *Hardening of Bearings of Sintered Iron Powder.* Iron powder is mixed with Va, Ti, Cr, but not with Cu, pressed and sintered; during the cooling period the body is hardened in a stream of N_2.

(2190) U. S. 2,372,202; 2,372,203 (1945). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Treatment of Bearings.* Bearings are made by pressing metal powders in suitable dies, sintering, and applying an age-hardening heat treatment.

(2191) Brit. 588,861 (1947). Imperial Chemical Industries Ltd., K. J. Forrest and W. O. Alexander, *Heat Treatment of Metals and Alloys.* Hydrides of Ca and Na are used for producing a protective atmosphere under conditions of severe heat treatment for hardening and annealing.

(2192) Austrian 162,875 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Bodies.* The sintered bodies are heat treated at 750° C. (1380° F.) for one hour.

B. Impregnation Treatment

i. With Metals

(2193) German 300,699 (1917). L. Reimann, *Production of Bodies from Metal Compounds.* Mixtures of Fe, Ni, and Cr powders are pressed to a body with a low weight per volume, heated and sintered, and then immersed in a bath of molten copper.

(2194) U. S. 1,342,801 (1920). C. L. Gebauer, *Process of Producing Metal Bodies.* Process of producing metal bodies consists of molding a porous powdered metallic constituent of high melting point, applying to it on the surface of the body a layer of a constituent of lower melting point, then subjecting the body to a temperature sufficient high to melt the constituent of lower melting point, and permitting the latter to penetrate the pores of the former.

(2195) Brit. 148,533 (1921). L. Reimann and H. Leiser, *Metallic Alloy.* Metal powders, *e.g.* Fe, are pressed into the form of a porous body, heated and dipped into a liquified metal, *e.g.* Cu.

(2196) U. S. 1,395,269 (1921). C. L. Gebauer, *Production of a Composite Metallic Article.* A layer of a fusible metal is molten and introduced in non-divided state into a main body portion of finely divided particles of highly refractory metal closely composed together, completely filling the interstices between the particles near the surface of the body.

(2197) German 349,681 (1922). L. Boudreaux, *Brush Contact.* A brush contact of porous metal is made by filling the pores with a metal of lower melting point.

(2198) Brit. 195,093 (1923). General Electric Co. Ltd., *Preparation of Shaped Objects and Tools.* Porous pieces of WC are soaked and saturated with a molten metal, *e.g.* iron.

(2199) Brit. 224,639 (1924). British Thomson-Houston Co. Ltd., *Composite Metal Bodies.* The method of production comprises assembling self-packing metal particles into a body, adding a metal of lower melting point, to fill the open spaces in the body, and subjecting the whole to heating, to melt the lower melting metal and to cause it to flow into the open spaces.

(2200) U. S. 1,512,191 (1924). H. Baumhauer (General Electric Co.), *Hard Tools and Process for Making Them.* A method of producing refractory carbide materials involves impregnating and saturating the pores of the body with iron.

(2201) U. S. 1,552,184 (1925). N. H. Adams (General Electric Co.), *Production of Metal Compositions for Electrodes.* A formed composition of W and Cu is produced by heating the article from W powder high enough to sinter the hard particles into a porous body, and then impregnating it with the lower melting Cu.

(2202) Brit. 245,437 (1926). British Thomson-Houston Co., Ltd. and N. H. Adams, *Tungsten-Powder for Bearings, Welding Electrodes etc.* Method of making articles of hard and soft metals comprises heating particles of W to a temperature high enough to cause them to sinter into a more coherent mass, and impregnating the mass with the fused soft metal.

(2203) German 436,678 (1926). Allgemeine Elektrizitäts Gesellschaft, *Electrode.* A porous electrode body consisting of W or Mo is infiltrated with molten Cu to produce a homogeneous body.

(2204) German 443,911 (1927). Patent Treuhand Ges. fur Elektrische Glühlampen m.b.H. and H. Baumhauer, *Production of Drawing Dies.* Porous parts produced from W-carbide or Mo-carbide are impregnated with a lower melting metal, *e.g.* Fe.

(2205) Brit. 300,972 (1928). R. Walter, *Dense Sintered Metals Or Metal Carbides.* To increase the density of metals, such as W, Mo or Ta, or their carbides, they are caused to absorb one or more metals of lower melting point such as Fe, Cr, etc.

(2206) French 660,321 (1929). R. Walter, *Production of Hard Metal Bodies with Compacted Texture.* Bodies of WC or Mo_2C are impregnated with Stellites.

(2207) German 521,785 (1931). R. Walter, *Production of Dense Sintered Metals.* Sintered carbides are densified by infiltration with small quantities of Co, Cr, or Co plus Cr plus one or more metals of the Cr-group.

(2208) U. S. 1,803,882 (1931). R. Walter, *Hard Alloys Manufacture.* Pressed and sintered alloys as W or WC are covered with metals of lower melting point, such as Cr or Co, and heated until the molten metals fill out the pores of the pressed body.

(2209) U. S. 1,822,682 (1931). J. A. Weiger (P. R. Mallory & Co.), *Valve Seat For Use in Conduits Adaptable to Convey Highly Erosive Fluids.* Method of production comprises forming a body of porous W and impregnating it with a non-corrosive, low-melting point metal.

(2210) French 740,919 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Production of Hard Metal Composition.* Porous, partly fritted metal carbide is impregnated with a soft metal of lower melting point.

(2211) U. S. 1,848,437; 1,848,438 (1932). G. N. Sieger and J. A. Weiger (P. R. Mallory & Co., Inc.), *Metal Alloy.* A porous base of metallic W is impregnated with a metal of lower melting point and 3% C and P, as hardening material.

(2212) Brit. 387,427 (1933). British Thomson-Houston Co. Ltd. and R. Palmer, *Infiltration of Hard Metal Composition for Welding Rods, Bearings, Polishing Wheels.* W-carbide with an agglutinant is shaped and heated to burn out the latter; molten Ag, Cu is then filled into the porous mass.

(2213) U. S. 1,910,884 (1933). G. J. Comstock (Firth Sterling Steel Co.), *Production of Hard Metals for Tools and Dies.* Separate layers of a compacted body of hard abrasive particles having interstices between the particles and a compacted body of bonding metal particles are heated, thus causing the bonding metal to flow into the interstices of the abrasive particles.

(2214) Dutch 36,878 (1934). N. V. Wallramit Handel Mij., *Infiltration of Porous Bodies.* Powdered metal carbides are filled into a form, and covered with the lower melting metal in powdered or granular form, then heated to a temperature above the melting point of the lower melting metal.

(2215) Austrian 144,222 (1936). Gebr. Böhler & Co., A. G., *Shaped Masses of Hard Carbides by Impregnation.* Unsintered powdered carbide is consolidated by allowing a molten metal to seep in.

(2216) German 641,164 (1936). Gebr. Böhler & Co., A. G., *Shaped Masses of Hard Carbides by Impregnation. Cf.:* Austrian 144,222 (No. 2215).

(2217) German 643,567 (1937). N. V. Molybdenum Co. and P. Schwarzkopf, *Production of Binary Alloy.* Method of producing a binary alloy comprises sintering the high melting metal, which is then filled with 20% of a low melting metal such as Cu, Ag, Al or Pb.

(2218) U. S. 2,096,924 (1937). P. Schwarzkopf, *Composite Structural Product and Method of Making It.* A method is claimed of making a composite of metals of the W, Mo, Ta, Ti group, present as sponge-like matrix, and a metal of a 2nd group comprising Ag, Au, Cu, Ni, Fe, or Al, which is impregnated into the sponge.

(2219) Canadian 390,025 (1939). General Motors Corp., *Impregnation of Porous Bodies.* The sintered body of Cu powder is first immersed in a bath of fluxing agent and then in a melt of Sn.

(2220) German 672,257 (1939). Meutsch, Voigtländer & Co., *Production of Pieces with Hard Metal Inserts.* Hard carbide metal powder is filled into a mold and held there by a wire gauze, through which the support metal, laid also into the mold, may infiltrate through the powder during sintering.

(2221) German 681,403 (1939). Deutsche Edelstahlwerke A. G., *Hard Metal Mixture by Impregnation.* High melting powdered metals such as W, Mo, Ta or their oxides and at least one of the metals Ti, V, Zr, Cb are sintered; then the product is rolled, forged or drawn, whereupon it is impregnated with Cu, Ag, Al above the melting temperature of the low melting metal.

(2222) German 682,546 (1939). Meutsch, Voigtländer & Co., *Production of Pieces with Hard Metal Inserts.* The hard metal powder is filled into a form and is strengthened by impregnating and over- or under-casting the support metal.

(2223) German 682,769 (1939). Meutsch Voigtländer & Co., *Production of Pieces with Hard Metal Inserts.* Addition to German 672,257 (No. 2220) comprises using first a more noble and harder metal which infiltrates the hard carbide metal during sintering, and then using another less noble metal, to complete the filling of the mold.

(2224) German 683,447 (1939). Meutsch, Voigtländer & Co., *Production of Sintered Formed Bodies.* A form is filled with the metal carbide powder, the binder is laid on top of the charge and the form is heated to a temperature below the melting point of the carbide particles, resulting in infiltration.

(2225) Swiss 201,050 (1939). A. Kratky, *Production of Hard Metal Bodies.* The porous metal carbide body is coated with a metal or metal alloy, and then annealed, to impregnate the pores with metal.

(2226) U. S. 2,190,237 (1940). R. P. Koehring (General Motors Corp.), *Method of Making a Composite Metal Structure.* The method comprises sintering finely divided non-compacted metal powder to form a matrix and impregnating it with flux, impregnating the porous metal matrix with a mixture of metals which includes one metal readily alloyable and the other not alloyable, with the metal in

the matrix, and heating above the impregnating temperature to leave the less alloyable metal dispersed between the pores of the matrix.

(2227) U. S. 2,192,792 (1940). L. L. Kurtz (General Motors Corp.), *Sintering and Impregnating Briquettes of Powdered Metal, such as Iron or Steel.* A briquette of powdered metal is immersed into molten metal, not readily soluble in it, after having been kept above the melting temperature of the bath metal during sintering.

(2228) U. S. 2,193,435 (1940). W. H. Smith, *Uniting Finely Divided Iron with other Metals.* Sintered Fe-containing Fe-oxide is dipped into a bath of acid slag containing molten non-ferrous metals which replace the oxide.

(2229) U. S. 2,198,240 (1940). A. L. Boegehold (General Motors Corp.), *Impregnation of Bearing Material.* A bearing of porous Cu-base sponge metal is impregnated with corrosion-resistant Pb-base babbitt containing 2-15% Sb plus 2-15% Sn, balance Pb.

(2230) Belgian 446,469 (1942). Fides Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Material Having a High Permanent Stability.* It consists of brittle intermetallic compounds of relatively high melting point (1400° C.; 2550° F.), and is produced by filling the structure which after heating has microscopic or macroscopic pores with a second metal.

(2231) U. S. 2,294,404 (1942). F.R. Hensel and E.I. Larsen (P.R. Mallory & Co.), *Production of Silver Bearing.* A compressed and sintered Ag-powder bearing of a density between 7.2 and 10.3 is impregnated with molten lead acting as a filling.

(2232) Brit. 565,520 (1944). Cutanit Ltd. and M. Littmann, *Bodies Formed of Metal Powder.* Elementary bodies are formed by molding unsintered powders under pressure and then sintering; these are united into complex bodies by applying to their abutting surfaces a boundary material having a lower melting point than the final sintering temperature. The complex body is heated up to the melting point of the boundary material, which is chosen from the group of Cu, Ni, Ag, Co, Sn or their alloys with each other or with Cd, and the liquid metal is then infiltrated into the elementary bodies.

(2233) U. S. 2,364,713 (1944). F. R. Hensel (P. R. Mallory & Co.), *Treatment of Bearing.* A bearing is formed of powdered Fe, Ni, or Co compacts impregnated with Hg for use against steel or other surfaces which do not amalgamate.

(2234) Brit. 571,128 (1945). General Motors Corp. and R. R. Bourne, *Method of Impregnating Porous Metal Parts. Cf.:* U.S. 2,401,221 (No. 2236).

(2235) U. S. 2,390,805 (1945). J. A. Merryman and E. M. Wharff, Jr. (Westinghouse Electric & Mfg. Co.), *Method of Making Metallic Articles.* It consists of spraying low-carbon steel to form a porous structure, heating it in a reducing atmosphere, applying a brazing metal of Cu or Cu-base alloy, and heating to fill the pores of the sprayed steel metallic article with the Cu or Cu-alloy.

(2236) U. S. 2,401,221 (1946). R. R. Bourne (General Motors Corp.), *Method of Impregnating Porous Metal Parts.* Porous Fe articles are impregnated with Cu by immersing them in molten Cu, by providing sufficient iron dissolved in the Cu to eliminate the dissolving action of the Cu on the porous Fe body.

(2237) U. S. 2,401,483 (1946). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Projectile and Method of Making It.* A shell body consisting of sections comprising compact bonded masses of metal powders is immersed in a body of molten metal of lower melting point.

(2238) Brit. 590,412 (1947). Mallory Metallurgical Products Co. and F. R. Hensel, *Impregnation of Metallic Composition with Bismuth.* Porous compacts of alloys containing Cu, Ag, Al, W, Mo are impregnated with 40-60% Bi at 625° C. (1150° F.) in H_2-atmosphere.

(2239) Brit. Appl. 10653/47; 10654/47 (1947). American Electro Metal Corp., *Method of Producing Infiltrated Ferrous Bodies of Complicated Shape.* Improvement of Brit. Appl. 10652/47 (Brit. 629,326, 1949, No. 2247). The expansion due to the impregnation is compensated by varying the C content to produce the corresponding shrinkage in the presintering stage. Impregnation of a gear wheel is made by filling the bore of the wheel with a mixture of oxide-reduced Cu, ball-milled Mn and carbonyl Fe powders.

(2240) Brit. Appl. 11363/47 (1947). American Electro Metal Corp., *Stainless Steel Parts.* Stainless steel parts are made by compacting a 18/8 powder to a porosity of 15%. The pressing is placed into a mold of Al_2O_3 and impregnated by contact with a pressing of 75-85% Cu, 5% Fe, 5-10% Ni, 5-10% Mn.

(2241) U. S. 2,415,196 (1947). R. H. Steinberg and D. Steinberg, *Metallic Impregnated Graphite for Use as Bearings.* Graphitic waste material from steel mills (kish) is boiled with $CuSO_4$ to replace the Fe contained in the kish by Cu, and yield a product of graphite impregnated with powdered Cu.

(2242) U. S. 2,422,439 (1947). P. Schwarzkopf (American Electro Metal Corp.), *Method of Manufacturing Composite Structural Materials.* The method comprises forming a body of a major portion of a substance having a high melting point and having intercommunicating pores, contacting that porous body with a minor portion of a lower melting metal in an amount sufficient to fill the pores, and slowly moving the porous body and metal in contact downward through an upright confined furnace space.

(2243) U. S. 2,456,779 (1948). C. G. Goetzel (American Electro Metal Corp.), *Composite Material and Shaped Bodies Therefrom.* The method of production comprises compacting Fe powder to form a shaped porous body, contacting it with a cuprous infiltrant associated with another metal, such as Fe, Mn, Ni, Cr, Si, Ti, heating the body and infiltrant to the temperature needed for the infiltration, and further heating to alloy the Cu and the other metal with the Fe.

(2244) Austrian 163,634 (1949). Metallwerk Plansee G.m.b.H. and K. Mallener, *Production of Dense Tubular Bodies.* It comprises pressing a core (*e.g.* Cu) in the metal body (*e.g.* Fe) which melts during sintering so that the metal is soaked into the pressed body.

(2245) Austrian 164,473 (1949). Metallwerk Plansee G.m.b.H., *Production of Material for Bearings.* The skeleton body of Fe is impregnated with a bearing metal.

(2246) Brit. 613,041 (1949). American Electro Metal Corp., *Methods of Producing Alloy Bodies.* A highly porous pressing of a given alloy is impregnated with an alloy having the same constituents, but a different composition and lower melting point. For example, a 70/30 brass is made by pressing a 95/5 brass to a body of 55% density, which is then impregnated with 50/50 brass.

(2247) Brit. 629,326 (1949). American Electro Metal Corp., *Method of Producing Infiltrated Ferrous Bodies of Complicated Shape.* The parts are composed of two or more simple shapes, which are pressed from Fe powder to a porosity of 10-35%. The parts are then assembled and impregnated by contact with a pressing of 90% Cu, 3-5% Fe, 3-5% Mn, and P, Ti, Cr, Ni in a total amount of 15%.

ii. With Nonmetals

(2248) German 218,887 (1910). V. Löwendahl, *Metal Impregnated with Lubricant.* Metal powder, *e.g.* Cu and Zn, is mixed with material which is vaporized, *e.g.* NH_4NO_3, by heating, then sintered into a porous body whose pores are filled with a lubricant by pressing or sucking in.

(2249) U. S. 986,519 (1911). C. E. Swett, *Rendering Porous Metal Dense.* This is accomplished by filling the pores of a metal body with a reducible compound of the same metal in the fluid state and then reducing the compound in the pores to metal.

(2250) U. S. 1,051,814 (1913). V. Loewendahl, *Process of Manufacturing Porous Metal Blocks Suitable for Impregnation.* Metallic powder is mixed with NH_4NO_3, pressed into porous block form, heated to eliminate the NH_4NO_3, and impregnated with a substance capable of penetrating pores.

(2251) U. S. 2,155,592; 2,155,593 (1939). C. Hardy (Hardy Metallurgical Co.), *Preventing of Adherence of Congealed Substances to Metals.* A refrigerator tray is made by impregnating porous metal powder with a repellent substance, such as wax, which prevents congealed liquid such as ice from adhering to the metal by freezing.

(2252) U. S. 2,155,651 (1939). C. G. Goetzel (Hardy Metallurgical Co.), *Manufacture of Aluminum Alloys.* Age-hardenable aluminum alloys with controlled porosity are impregnated with wax.

(2253) Canadian 399,182 (1941). General Motors Corp. and R. P. Koehring, *Porous Bearing Metal.* The porous sintered metal of Cu and Ni is immersed in a hot mixture of graphite and binder.

(2254) German 741,600 (1943). Deutsche Waffen- und Munitionsfabriken A. G., *Use of Paraffin for the Impregnation of Sintered Bodies.* Sintered bodies, such as shell driving bands produced from Fe powder, are impregnated with paraffin as rust preventive, whose pH value is brought up to 5.4 by additional oxidation.

(2255) German 745,806 (1944). H. Vogt, *Soaking of Porous Sintered Bodies with Solution of Metal Salts.* A pressing, *e.g.* bearing bushing, produced from spongy Fe powder is pressed to a specific gravity of 5 with 33% porosity, then impregnated with a saturated solution of $FeSO_4$ and sintered at 1050° C. (1920° F.); the increase of weight is only 0.45%, the increase of strength is 2.5 times.

(2256) U. S. 2,365,562 (1944). R. P. Koehring (General Motors Corp.), *Method of Making Porous Metal Bearings.* It consists of lining the bore of a porous metal bearing with soft metal powder and simultaneously impregnating the bearing with oil and sizing the bore.

(2257) U. S. 2,376,706 (1945). J. H. Lum (Monsanto Chemical Co.), *Impregnating Pressed Metal Articles.* Fe, Cu, Al, Zn, Ni, Co, or brass powder can be processed by briquetting and sintering to an improved and denser product by a final impregnation treatment with monomeric vinyl compounds.

(2258) Brit. Appl. 7091/47 (1947). American Electro Metal Corp., *Composite Material Containing Polymers.* Sintered porous Fe compacts are impregnated with molten polymers by immersing the compact in the molten polymers under vacuum; then admitting N_2 and temporarily opening the tube for decanting the excess of polymers.

(2259) Brit. 616,537 (1949). S. A. Le Carbone-Lorraine, *Electrodes and Brushes for Electric Machines.* Cu-graphite brushes are impregnated with super-polyamides, either from a solution under vacuum, or from a melt in N_2.

C. Surface Treatment (Coating, Spraying, Plating, Carburizing)

(2260) U. S. 1,626,235 (1927). D. S. Gustin (Westinghouse Lamp Co.), *Getter.* A getter is applied to a lamp filament by dipping a portion of it into powdered Al.

(2261) Brit. 309,536 (1929). Siemens & Halske A. G., *Filaments for Incandescent Bodies.* A core of W and a coating of Re is used in filaments for electrical incandescent lamps, vacuum tubes and the like.

(2262) Brit. 331,540 (1930). I. G. Farbenindustrie A. G., *Treating of Electrodes for Secondary Cells.* Compressed porous bodies of Fe or Fe_3O_4 whose pores contain an active mass are coated with a metal more electro-chemically resistant than the porous body.

(2263) German 564,081 (1932). Fried. Krupp, A. G. and A. Fehse, *Treatment of Articles from Sintered Carbide Materials.* Shape and size of sintered carbide articles can be varied by exposing them to surface attack by a corrosive or oxidizing gas at elevated temperature (*e.g.* air at 800° C.; 1470° F.), either locally or uniformly over the entire surface, whereby a loose surface layer is formed which can be removed mechanically, *e.g.* by brushing.

(2264) U. S. 1,981,878 (1934). S. Ruben (Sirian Lamp Co.), *Coating of Filament.* A filament is made by coating a wire of a refractory metal, such as Mo, with powdered Be, that has been incorporated in a solution of amy acetate in nitrocellulose.

(2265) Swiss 183,738 (1936). Rheinische Metallwaren- und Maschinenfabrik and G. Boecker, *Production of Hard Metal Bodies.* The auxiliary metal is electrodeposited on and between the hard carbide particles of the preformed body connected with the cathode until all cavities are filled up.

(2266) Austrian 152,553 (1938). A. Kratky, *Coating Carbides.* Carbides are coated with a powder or foil of a metal having a melting point below that of the carbide, but above that of Cu to facilitate brazing to holders.

(2267) German 750,365 (1944). Anonymous, *Electroplating of Sintered Carbides.* Distortion of sintered carbides during brazing is prevented by a cathodic etching in caustic potash solution at 6 volts for 1 min., electrodeposition of an Fe coating, heating in non-oxidizing atmosphere and finally electroplating the desired metal onto the Fe coating.

(2268) U. S. 2,387,872 (1945). M. E. Bell (Westinghouse Electric & Mfg. Co.), *Treatment of Bearing Surfaces with Lubricants.* Compounds such as sulfides, selenides and tellurides of W, Mo, and Ti are applied to bearing surfaces, pressed onto them and heat treated for reducing the friction in bearing members.

(2269) Brit. 580,262 (1946). The British Piston Ring Co. Ltd., *Metal Articles.* Surface porosity of machined powder metallurgy parts is restored by etching or pickling or electrochemical treatment.

(2270) Canadian 447,622 (1946). E. A. Thurber and L. A. Wooten, *Process of Carbiding.* Thoriated W cathodes are carburized on the surface by glowing at 2275° C. (4120° F.) in an inert gas containing 1-5% paraffin hydrocarbon vapor.

(2271) Brit. 603,762 (1948). Sintered Products Ltd. and J. W. Lennox, *Manufacture of Porous Parts.* Porous sintered parts are electroplated with a metal whose powder does not sinter easily, under such conditions that the porosity is not destroyed.

(2272) Brit. Appl. 3836/48; 3837/48 (1948). Ekstrand & Tholand, *Production of Plated Metal Articles, Especially Bearings.* A process is disclosed for Ni-plating of green pressings of 99% Fe, 1% graphite, which are then sintered in H_2 at 1100°C. (2010°F.) for 1 hr., and cooled; the coating partly diffuses into the porous compact, and does not peel off even in coining. Fe and Fe-Cu bearings are plated with Ag, Pb, Sn, Sb, Cd, etc. by the same method; typical compositions of the green pressings are 98% Fe, 1% graphite, 1% Ca-stearate; 73% Fe, 25% Cu, 1% graphite, 1% Ca-stearate; or 69% Fe, 27% Cu, 3% Sn, 1% Ca-stearate.

(2273) Austrian 162,867 (1949). Gebr. Böhler & Co. A. G., *Production of Corrosion-Resistant Iron or Steel Bodies.* By agitation of the unsintered or porous sintered parts with vapors of $CrCl_2$.

(2274) Austrian 162,893 (1949). Gebr. Böhler & Co. A. G., *Formed Bodies.* Pressed porous Fe bodies are nitrided at 150-350° C. (300-660° F.).

(2275) Austrian 162,971 (1949). Gebr. Böhler & Co. A. G., *Sintered Metal Parts with High Elasticity.* The porous body is supplied continuously with a layer of a phosphate.

8. FINISHING, JOINING AND TESTING OF PRODUCTS

(2276) U. S. 1,261,110 (1918). F. A. Fahrenwald (Government of U. S. A.), *Coating Tungsten or Molybdenum Articles.* The article is prepared for soldering or brazing by heating to 1350° C. (2460° F.) for 30 seconds in contact with molten Au and a flux containing oxygen salt of alkali metal.

(2277) U. S. 1,265,575 (1918). D. K. Wright (General Electric Co.), *Method of Shaping Filaments.* The method comprises winding the wire between two rigidly mounted conducting supports, and passing an electric current through the wire, in such a way that the portions between the supports will be more heated than the portions surrounding the supports.

(2278) Brit. 289,553 (1928). N. V. Philip's Gloeilampenfabrieken, *Soldering Metals or Metal Alloys.* For soldering W or Mo to other metals, a solder comprising Cu and a deoxidizing admixture are used.

(2279) French 705,132; 705,133; 705,134 (1931). Fried. Krupp A. G., *Brazing of Hard Metal Body.* A cylindrical body of an alloy containing WC is brazed with a steel composition, containing 0.3% C, 3% Cr, 9% W and 0.3% V, having a good annealing temperature.

(2280) Brit. 355,127 (1931). Fried. Krupp A. G., *Tools with Cutting Edges of Tungsten Carbide Composition.* WC is Cu-brazed onto 9% W-steel tool shafts.

(2281) U. S. 1,823,709 (1931). G. F. Taylor (General Electric Co.), *Method of Producing Openings through Hard Metals.* Openings through hard metal compositions are produced by dissolving a quartz stem embedded in the hard sintered structure.

(2282) U. S. 1,843,549 (1932). L. G. Firth (Firth Sterling Steel Co.), *Method of Securing Tips to Tool Holders.* A WC cutting tip is secured on a tool holder by lubricating the tip with a metallic lubrication medium and heating and cooling it.

(2283) U. S. 1,860,275 (1932). W. R. Chapin, *Brazing of Tungsten Carbide Bits onto Steel Shanks.* Cu powder is used as brazing element, and borax as flux. The bit is pressed onto the steel shank, and the assembly is heated while under pressure.

(2284) German 614,058 (1935). Fansteel Products Co., *Joining of Tips of Metal Carbides with Shanks.* The tips of a sintered mixture of Fe- and Ta-carbide or boride are dipped in fused alkali for roughening the surface, then coated with a mixture of Ag and Zn as solder, and then pressed on the shank with the solder in intermediate position.

(2285) German 625,028 (1936). Fried. Krupp A. G., *Production of Hard Metal Articles of Large Dimensions.* The hard metal bodies are joined by interposition of hard metal powder and using graphite as protecting agent against oxidation during welding under pressure.

(2286) U. S. 2,124,236 (1938). J. B. Ragsdale and R. G. Goodwin (Globe Oil Tools Co.), *Setting Hard Cutting Materials such as Well Drilling Tool Tips.* A cutting tool part is heated and inserted into a drill by means of a puddle.

(2287) U. S. 2,165,105 (1939). R. F. Krejci and W. P. Zabel (General Electric Co.), *Apparatus for the Manufacture of Filaments.* An apparatus for treating coiled lamp filaments and the like with cleaning fluids is disclosed.

(2288) U. S. 2,186,312 (1940). R. Wildermann, *Apparatus and Process for Welding of Electric Contacts.* Apparatus and operative details are disclosed for welding W-type metal contact tips on backings for electric contacts.

(2289) German 705,738 (1941). Siemens & Halske A. G., *Method for the Connection of Tungsten Leafs with Support.* Method for the connection of small tungsten plates and leafs with the basic metal comprises inserting a mixture of powders of the two metals between leaf and basic material and connecting parts by spot welding, thereby melting only the basic metal.

(2290) U. S. 2,266,305 (1941). W. E. Jominy and A. L. Boegehold (General Motors Corp.), *Wear Testing Machine.* An apparatus suitable for testing the wear resistance of metals from powders is disclosed.

(2291) German 717,429 (1942). I. G. Farbenindustrie A. G., *Welding of Hard Metal Carbide Pieces on Tools.* The first layer consisting of the Co-containing hard metal is bonded to a second layer of the cutting alloy containing less hard metal, so that it can be repaired by oxy-acetylene welding.

(2292) German 719,824 (1942). Meutsch, Voigtländer & Co., vormals Gewerkschaft Wallram, *Welding on Hard Metal Pieces to Drills.* The cutting pieces are coated with a protective coating of Cu against oxidation prior to welding with a torch.

(2293) U. S. 2,385,198 (1945). E. W. Engle (Carboloy Co.), *Method for Forming Drawing Holes in Carbide Die Nibs.* It comprises the electrolytic and mechanical removal of material from the sintered carbide die nib.

(2294) U. S. 2,390,252 (1945). J. T. Hayward, *Apparatus for Determining Permeability of Porous Media.* It comprises an elongated tubular body with inlet and outlet and a tapered plunger, the clearance between plunger and tubular body being such as to define a fluid passage constraining a laminar flow of fluid therethrough.

(2295) Brit. 578,408 (1946). Carborundum Co., *Finishing of Hard Alloy Dies with Abrasive Coated Sheets or Belts.* WC or other hard alloy dies are re-sized more rapidly by using a leather belt coated with a mixture of diamond grit and fine SiC.

(2296) U. S. 2,392,050 (1946). L. S. Kupersmith and C. F. Wirt (S. K. Wellman Co.), *Apparatus for Finishing Bimetallic Articles.* An apparatus is disclosed for finishing the edges of the facings of a bimetallic article of the type having a facing of sintered powdered metal bonded to the face of an annular core of solid metal.

(2297) U. S. 2,404,157 (1946). F. W. Ahalt (Western Electric Co.), *Brazing of Tungsten Wires.* W-filaments are bonded to W-lead wires by use of Ni as brazing material.

(2298) Brit. 588,177 (1947). Mallory Metallurgical Products Co. Ltd., *Treatment of Electrical Contacts.* Contacts of CdO and Ag are etched with a 50% aqueous solution of HCl to improve the brazing properties. W-Ag or Mo-Ag contacts are treated by immersion in molten $NaNO_3$.

(2299) French 862,261 (1941). S.A. Carbone-Lorraine, *Brazing Cemented Carbides.* Brazing hard carbides to Fe alloys is accomplished by using an alloy of 60% Cu, 15% Co, 25% Mn.

(2300) Brit. 603,123 (1948). London Electric Wire Co. and Smiths Ltd., *Production of Holes in Sintered Articles.* WC dies are made by drilling the pressings with the aid of a copying mechanism.

(2301) Brit. 609,957 (1948). British Thomson-Houston Co. Ltd., *Grinding Machine.* Spherical pressings are ground to shape automatically between two grinding wheels, then sintered.

(2302) U. S. 2,434,237 (1948). S. K. Wellman (S. K. Wellman Co.), *Apparatus for Bonding Metal Briquettes to Curved Surfaces.* A brazing apparatus is disclosed for bonding metal powder compacts to curved surfaces, particularly for bonding compacted brake liners to brake drum surfaces.

(2303) U. S. 2,457,283 (1948). F. P. Slater, *Tungsten Carbide Tool Grinder.* A rotating grinding element is mounted in a reservoir with a portion below the level of the liquid coolant.

(2304) U. S. 2,466,095 (1949). J. F. Gall and H. C. Miller (The Pennsylvania Salt Manufacturing Co.), *Electrochemical Process for Polishing Tantalum.* The metal is made anodic in an aqueous bath containing 75-98% H_2SO_4 and 2-7% HF. A mirror like polish is produced at an anodic current density of 40-160 milliamperes per sq. cm.

(2305) U. S. 2,474,643 (1949). C. D. Webb (Carboloy Co. Inc.), *Method of Brazing Cemented Carbides to Steel.* Cu strip 0.01 in. thick is coated with Ag solder 0.005 in. thick on either side, and pieces of the same size as the carbide tips to be brazed are blanked out. The brazing temperature should lie intermediate between the melting temperatures of Cu and the Ag solder, *i.e.* at 650-800° C. (1200-1470° F.).

(2306) U. S. 2,491,346 (1949). A. Wetzel (Carboloy Co., Inc.), *Fixture for Grinding Twist Drill Tips.* A fixture is provided for grinding a cemented WC twist drill tip or ingot.

(2307) U. S. 2,491,839 (1949). R. B. Tinker (General Electric Co.), *Process of Electroplating a Sintered Ferrous Article.* Invention is applicable to sintered metal objects manufactured from metallic powders which have been compacted, preformed and molded under high pressures and then sintered. Article is subjected to the action of a basic solution and thereafter to the action of an acidic solution prior to electrolytically depositing a metal coating, *e.g.*, Ni, Cr, Pd.

(2308) U. S. 2,492,214 (1949). D. C. Fonda, *Method of Marking Tungsten Carbide.* A process is provided for marking WC gage blocks by using an electric current passing through acid, which contacts the surface to be etched.

III. Powder Metallurgy Products, Their Compositions and Manufacture

1. REFRACTORY METALS AND ALLOYS

A. Tungsten and Molybdenum

(2309) U. S. 575,002 (1893). A. De Lodyguine, *Illuminant for Incandescent Lamps.* An incandescent illuminant for electric lamps is composed of a metallic body of W or Mo and contains a conducting fillet of different material, as inner base or temporary support.

(2310) U. S. 575,668 (1894). A. De Lodyguine, *Illuminant for Incandescent Lamps.* An illuminant for electric lamps is composed of an incandescent body of Mo and contains a Pt fillet.

(2311) U. S. 401,120 (1889). T. D. Bottome, *Manufacture of Filaments.* By saturating a C filament with W compound and reducing the compound to metallic tungsten, a filament of W is obtained.

(2312) Brit. 23,899/1904 (1904). A. Just and F. Hanaman, *Manufacture of Filaments.* W or Mo or their compounds are mixed with organic binder, formed and carbonized, whereupon C is removed chemically.

(2313) Brit. 11,949/1905 (1905). A. Just and F. Hanaman, *Manufacture of Incandescing Filaments.* A C filament, coated with W or Mo, is submitted for a short time to highest white heat in an inert gas, whereby the carbon core is completely absorbed by the metal.

(2314) Brit. 7655/1906 (1906). H. Kuzel, *Process for Increasing Electric Resistance of Filaments.* The incandescing bodies of W, Mo, V, Ta, or Ti or their alloys are brought into contact with small quantities of B, C, or Si, or their compounds, which are decomposed by heat, forming a coating on the filaments.

(2315) Brit. 15,510/1907 (1907). Deutsche Gasglühlicht A. G., *Manufacture of Filaments.* Removal of the C content from the raw W filament is effected by heating in H_2 atmosphere which contains traces of water vapor.

(2316) Brit. 18,053/1907 (1907). R. Jahoda, *Manufacture of Filaments.* W or Mo powder is mixed with an oxide of Th, Ti, Va or of Si or B; and a binding agent, containing C, is added; the mixture is shaped and sintered by electrical current in presence of H and C.

(2317) German 192,290 (1907). H. Kuzel, *Elevation of Resistivity of Filaments.* The filament of refractory metal is contacted with small quantities of B, Si, or C, and heated to impregnate the surface of the filament.

(2318) U. S. 842,546 (1907). J. A. Heany, *Electric Lamp Luminant.* Electric lamp luminants are made from powdered W or Ti molded to shape and sintered.

(2319) German 194,348 (1908). H. Kuzel, *Process for the Manufacture of Filaments from Tungsten and Other Refractory Metals for Electric Incandescent Lamps.* A metal, such as W, Mo, Ta, etc., in colloidal state is formed without binder, dried, and heated to white heat.

(2320) German 197,382 (1908). Siemens & Halske A. G., *Production of Filaments.* W powder is rammed into a ductile tube and worked together by drawing or rolling, whereupon the metal tube is removed by melting or chemical action, and the W powder mass is sintered near the melting point of the metal.

(2321) German 199,961 (1908). H. Kuzel, *Elevation of Resistivity of Filaments.* Addition to German 192,290 (No. 2317). Instead of admixing B or Si to W powder, compounds of As or Sb are admixed.

(2322) German 199,962 (1908). H. Kuzel, *Production of Filaments.* Addition to German 194,348 (No. 2319). Oxynitrides of W, which are produced by reduction of WO_3 with KCN, are used instead of the pure metal for the production of electric lamp filaments.

(2323) German 204,616 (1908). Siemens & Halske A. G., *Production of Filaments.* Addition to 197,382 (No. 2320). A very ductile metal with low boiling point is added to the W powder.

(2324) German 205,581 (1908). H. Kuzel, *Production of Filaments.* Addition to 194,348 (No. 2319). The metal in colloidal state is mixed with very fine powdered oxides of the same metal and heated in a reducing atmosphere.

(2325) Brit. 23,499/1909 (1909). The British Thomson-Houston Co., Ltd. and General Electric Co., *Treatment of Tungsten to Facilitate Working.* Treatment involves pressing sticks of W powder, sintering the sticks, swaging or rolling them into rods while heated, then drawing down the swaged rods.

(2326) German 206,142 (1909). Siemens & Halske A. G., *Production of Filaments.* Addition to German 197,382 (No. 2320). Into the outer tube is inserted a second tube which is very ductile.

(2327) German 206,911 (1909). H. Kuzel, *Production of Filaments.* Addition to German 194,348 (No. 2319). The colloidal filaments are heated directly by electrical current, without pre-heating, till sintering is completed.

(2328) German 207,395 (1909). Allgemeine Elektrizitäts Gesellschaft, *Method of Production of Filaments.* The process comprises mixing W or Mo powder with Cu powder, heating, extruding to filaments, and heating again in inert atmosphere to volatilize the Cu.

(2329) German 216,785 (1909). H. Kuzel, *Production of Filaments.* Addition to German 194,348 (No. 2319). Organic colloids are added to the inorganic colloids.

(2330) U. S. 908,682 (1909). A. Lederer, *Refractory Metals for Electric Lamps.* Manufacture of filaments comprises reducing a paste containing a refractory metal (such as W) oxide, C and 0.5% Al or Mg, by the passage of an electric current, so that the oxide of the auxiliary metal formed in the reaction is volatilized.

(2331) U. S. 908,930 (1909). H. Zerning, *Decarbonizing of Filaments.* The method consists of placing the filament of W in a vessel under vacuum and heating in the presence of phosphan (PN_2H) with or without an addition of P.

(2332) U. S. 914,354 (1909). H. Kuzel (General Electric Co.), *Filament.* Filaments are made from a plastic mass consisting of colloids of a refractory metal, such as W, mixed with Sb.

(2333) U. S. 927,935 (1909). W. v. Bolton (Siemens & Halske A. G.), *Filaments.* The process comprises surrounding each particle of W, Mo, Ta with a casing of a ductile metal, *e.g.* Ni, Cu, Al, Th, forming a cohesive mass of the metals, and then producing the filament by heating above the evaporation temperature of the ductile metal.

(2334) U. S. 930,723 (1909). W. v. Bolton (Siemens & Halske A. G.), *Process of Forming Electric Incandescent Lamp Filaments.* The process entails fitting into a tube of ductile metal a tube of a different ductile metal, inserting W powder into the latter tube, subsequently working the tubes and W into filaments, and removing tubes.

(2335) German 223,102 (1910). W. Majert, *Production of Filaments.* W powder is mixed with glycerine and tungstic acid to form a paste which is sprayed into filaments and then sintered.

(2336) U. S. 950,869 (1910). J. Schilling, *Making Amorphous Tungsten Powder.* Metallic W filaments for incandescent lamps are produced from amorphous W powder.

(2337) U. S. 963,872 (1910). W. D. Coolidge, (General Electric Co.), *Lamp Filament.* Refractory metal powder is mixed with a colloid of a less refractory metal and squirted into threads, which are treated to convert them into the metallic state, after which the colloidal metal is vaporized, and the refractory metal powder filament is sintered into a coherent mass.

(2338) U. S. 969,064 (1910). H. Kuzel (General Electric Co.), *Filament.* The process comprises producing filaments from a plastic mass containing peptizated colloidal metals, such as W, V, Ta, pressing the body into shape and thereby expressing the liquid, drying and heating the body for sintering.

(2339) Brit. 1,544/1911 (1911). W. C. Heraeus G.m.b.H. and C. Trenzen, *Manufacture of Filaments.* Sintering of partly decarbonized W.filaments is accomplished by externally heating them by means of a heated surrounding body of pure Ir in the presence of a reducing gas.

(2340) Brit. 23,499/1909 (1911). British Thomson-Houston Co., Ltd., *Use of Ductile Tungsten for Electric Light Filaments.* Method consists of the repeated working of a body of coherent W while hot until it becomes ductile at ordinary temperatures.

(2341) Brit. 17,469/1910 (1911). F. Eisner, *Metallic Filaments.* Filaments are manufactured from W or other refractory metals or their compounds. The binding medium is devoid of C and composed of hydrazine or its compound.

(2342) Brit. 4,159/1911 (1911). A. C. Hyde, *Ductile Molybdenum for Use as Filament Supports.* The process entails adding to Mo one percent of Fe, Ni or Mn and binding material, making a paste and squirting through die.

(2343) German 232,260 (1911). Siemens & Halske A. G., *Production of Filaments.* The W powder is mixed with Ni and formed, then Ni is driven off by a gas, *e.g.* CO, which forms a compound with Ni, without attacking the filament.

(2344) German 233,885 (1911). Siemens & Halske A. G., *Method for Production of Filaments.* Method for production of filaments comprises mechanically working a mixture of W with Ni and driving out the Ni after working by heating the body.

(2345) U. S. 1,011,708 (1911). A. O. Appelberg (General Electric Co.), *Treating Tungsten.* The process consists of mixing W and binder and oxide of W and pressing, heating to 1300° C. (2370° F.) to render it strong, machining, and heating to above 1600° C. (2910° F.) to purify and make it suitable for use as a conductor.

(2346) Brit. 18,351/1911 (1912). E. R. Grote, *Use of Ductile Tungsten for Lamp Filaments.* Method of producing metal filaments consists of passing the uncarbonized filament through an electric arc.

(2347) Brit. 18,467/1911 (1912). W. D. Coolidge, *Use of Powdered Tungsten in Lamp Filaments.* A rare earth oxide or a compound is added to powdered W in a preliminary treatment.

(2348) German 245,190 (1912). A. Pacz, *Production of Filaments from Colloidal Metals.* A soluble compound of a refractory metal, *e.g.*, $(NH_4)_2WO_4$, is mixed with a benzene derivative, *e. g.*, pyrogallol or gallotannic acid, to form a paste, and sintered.

(2349) German 251,997 (1912). Bergmann-Elektrizitäts-Werke A. G., *Pressed Bodies of Tungsten Powder.* The W powder is pressed without binder under high vacuum, then sintered in H_2 or under vacuum.

(2350) U. S. 1,018,502 (1912). A. Just and F. Hanaman (General Electric Co.), *Incandescent Bodies for Electric Lamps.* A filament consists of W in a coherent state and homogeneous throughout having its fusing point approximately at 3200° C. (5800° F.).

(2351) U. S. 1,023,295 (1912). H. Bresler (General Electric Co.), *Filaments.* Finely divided W or Mo is held together by a low-carbon-residue binder of ammonium viscose to make a filament coating paste.

(2352) U. S. 1,026,343; 1,026,344 (1912). W. D. Coolidge (General Electric Co.), *Filaments.* A filament-forming plastic is made from W powder mixed with a binder of warm amalgam of Cd, Hg and Bi, which is later on removed by volatilization.

(2353) U. S. 1,026,382; 1,026,383; 1,026,384 (1912). W. D. Coolidge (General Electric Co.), *Filaments.* The process comprises making filaments by incorporating W powder in a ductile alloy, shaping and treating to drive out all of the components except the W.

(2354) U. S. 1,026,392 (1912). C. A. Hansen (General Electric Co.), *Filaments.* Filaments are prepared from refractory metal powders such as W and a binder of a metal oxalate which decomposes and forms a refractory oxide.

(2355) U. S. 1,026,428 (1912). W. D. Coolidge (General Electric Co.), *Electrical Conductors.* Conductors suitable for use in incandescent lamps are made by sintering refractory metal, *e.g.* W, impregnated with a ductile metal, which is subsequently removed by volatilization.

(2356) U. S. 1,026,429 (1912). W. D. Coolidge (General Electric Co.), *Refractory Conductor.* The method entails impregnating refractory metal, *e.g.* W, with less refractory metallic material, shaping into conductors, and treating subsequently to remove all components except refractory metal.

(2357) U. S. 1,027,165 (1912). H. I. Wood (General Electric Co.), *Method of Producing Filaments.* The method entails vacuum heating a wire of Cd-amalgam impregnated W to drive off Hg and leave a coherent conductor containing Cd and W. The Cd is then volatilized and the remaining W is sintered.

(2358) U. S. 1,034,018 (1912). A. Lederer (Westinghouse Lamp Co.), *Manufacture of Tungsten Filaments for Incandescent Electric Lamps.* Homogeneous W filaments are made by preparing a paste of WO_2 and carbonaceous binding agent to reduce the WO_2.

(2359) U. S. 1,034,949 (1912). W. Arsem (General Electric Co.), *Producing Metal Filaments.* The process comprises fusing a low-melting-point metal in contact with a finely divided refractory material, such as Mo, and heating to a higher temperature to vaporize the low-melting metal.

(2360) U. S. 1,035,883 (1912). A. Lederer, *Manufacture of Exceedingly Thin Metallic Filaments for Electric Incandescent Lamps.* The process consists of heating in inert atmosphere a mixture of W and readily volatilizable metal and C in the presence of sufficient O_2 to oxidize all the C and to volatilize the metal.

(2361) U. S. 1,037,268 (1912). H. Kuzel (General Electric Co.), *Process of Manufacturing Incandescent Bodies.* Metallic filaments are prepared by mixing a refractory material such as Mo with a colloidal O-compound of a metal melting at very high temperature, then shaping, reducing, and consolidating by heating in reducing atmosphere.

(2362) U. S. 1,047,540 (1912). A. Lederer, *Manufacture of Tungsten Filaments for Incandescent Electric Lamps.* W filaments are made from raw filaments of benzidin tungstate, a suitable organic agglutinant and a small proportion of oxide of W.

(2363) Brit. 5,026/1912; Brit. 5,028/1912 (1913). Julius Pintsch A. G. and J. Hubers, *Tungsten and Other Powdered Metals for Rods or Wires.* A process for obtaining ductile filaments of W alloy consists of squirting a mixture of W with 1-4% of oxide of Th, Mg or Zr.

(2364) French 448,229 (1913). P. Schwarzkopf and S. Burgstaller, *Production of Bodies from Tungsten- or Molybdenum-Oxide Powder.* The powder is pressed without addition of a matrix powder and then heated in reducing atmosphere, to give metallic W or Mo bodies.

(2365) U. S. 1,071,325 (1913). A. Lederer, *Manufacture of Filaments for Electric Incandescent Lamps.* Filaments are squirted of a paste of WO_2 and organic agglutinant (ammoniacal solution of casein). The threads formed are subjected to dry distillation to make the W metallic, dense and coherent.

(2366) U. S. 1,075,563 (1913). C. A. Hansen (General Electric Co.), *Metal Filament.* A filamentary body comprising oxides of W and carbonaceous material is heated in H_2 atmosphere at low pressure at a temperature above 1200° C., (2200° F.), then heated to 2200° C. (4000° F.) in vacuum.

(2367) U. S. 1,077,674 (1913). W. D. Coolidge (General Electric Co.), *Production of Refractory Conductors.* Hardening shaped articles comprising refractory material, such as W, with an amalgam binder is effected by heating without formation of surface globules.

(2368) U. S. 1,079,777 (1913). A. Lederer, *Manufacture of Incandescent Bodies of Metallic Tungsten or Molybdenum for Electric Incandescent Lamps.* W filaments are produced by intimately mixing powdered W with amorphous S, shaping and heating to high temperature to remove S. Mo filaments are produced in like manner.

(2369) U. S. 1,082,933 (1913). W. D. Coolidge (General Electric Co.), *Tungsten and Method of Making Same for Use as Filaments of Incandescent Lamps.* W is made ductile by hot working a crystalline body of W until the structure is broken and fibrous structure develops.

(2370) Brit. 13,282/1912 (1914). Wolfram Laboratorium G.m.b.H., P. Schwarzkopf and S. Burgstaller, *Production of Masses of Tungsten, Molybdenum and Other Refractory Metals from Powder.* Workable masses of W or Mo are produced from powder, each particle of which consists of the metal and hydrogen in the same relative proportion, pressed into a mold and subjected to a combined reducing and sintering operation.

(2371) Brit. 26,287/1912 (1914). Westinghouse Metallfaden Glühlampenfabrik G.m.b.H., *Ductile Tungsten, Molybdenum for Lamp Filaments.* The process consists of adding to the pulverulent metal a small amount of a solution of a salt of an earth metal such as $CaCl_2$, Ba nitrate, Th nitrate or Zr oxide, forming bodies which are brought to glowing condition (sintered) and then hammering or drawing the resultant body.

(2372) Brit. 3,112/1913 (1914). J. Kremenezky, *Ductile Tungsten with Addition of Inert Refractory Materials for Use in Lamp Filaments.* Powdered W is mixed with 2½% of a heat-resisting inert substance such as ZrO_2, Al_2O_3, BeO or MgO.

(2373) Brit. 3,162/1913 (1914). Westinghouse Metallfaden Glühlampenfabrik G.m.b.H., *Ductile Tungsten or Molybdenum.* The process entails mechanical treatment of ingots containing refractory metals and one or more auxiliary ductile metals such as Ni, Fe, Cu; removing the latter after working the body but before it has assumed its final shape; then further mechanically working the remaining pure metal by hammering, rolling or drawing.

(2374) Brit. 5,150/1913 (1914). J. Canello, *Tungsten, Molybdenum, Osmium and Other Refractory Metals.* A process is given for the production of bodies of W in which the finely divided metal is mixed with Ni together with glycerine and compressed, dried and sintered.

(2375) Brit. 10,369/1913 (1914). Siemens Bros. & Co. Ltd., *Tungsten Powder to Line Refractory Crucible.* In a process for fusing W within a crucible protected from oxidation and contamination by an inert atmosphere, the crucible contains a lining of powdered W.

(2376) Brit. 10,918/1913 (1914). The British Thomson-Houston Co., Ltd. and General Electric Co., *Incandescent Electric Lamp.* The filament is so located that vapor produced during its operation is carried by convection currents in the gas and deposited in such a position that it does not interfere with the illumination from the filament.

(2377) Brit. 12,421/1913 (1914). C. Gladitz, *Tungsten Bars Suitable for Mechanical Treatment.* A process for the manufacture of W bars for mechanical treatment is characterized by the use of fluffy tungsten powder inoculated with a larger cluster crystal derivatives, pressing this mixture into a body, and submitting said body to a treatment which causes the growth of larger crystals during subsequent sintering.

(2378) Prit. 15,297/1913 (1914). F. Simpson, *Ductile Tungsten Filaments.* A process for the manufacture of W filaments in bulk consists of drying squirted filaments in air, heating a large batch together in dry O_2, re-oxidizing the batch and raising the temperature of the filaments in the absence of external oxiding means, and finally sintering.

(2379) Brit. 16,066/1913 (1914). E. A. Krüger, *Process of Producing Tungsten Filaments. Cf.:* U. S. 1,154,701 (No. 2391).

(2380) U. S. 1,086,088 (1914). G. P. Scholl (Westinghouse Lamp Co.), *Manufacture of Filaments for Tungsten Lamps.* A paste for filaments consisting of pure W and casein is extruded into wires and then sintered whereby the organic binder is removed.

(2381) U. S. 1,089,757 (1914). T. W. Frech (General Electric Co.), *Filaments.* Filaments are produced from WO_3 mixed with a small amount of a Th compound, oxidized and reduced, then ground, pressed and sintered.

(2382) U. S. 1,099,704 (1914). E. Hurwitz (General Electric Co.), *Filaments.* A filament of tungsten powder is sintered and then shrunk under tension into the desired shape.

(2383) U. S. 1,104,557 (1914). J. Scoular (Dick, Kerr & Co., Ltd.), *Manufacture of Metallic Filaments for Electric Incandescent Lamps.* W powder is mixed with a small proportion of Na_2SiO_3 to produce a paste, which is squirted to form a raw filament and then heated to make it metallic.

(2384) U. S. 1,111,698 (1914). A. J. Liebmann (N. Hofheimer), *Bodies for Filaments.* The process consists of mixing metal powders such as W or Mo with an oxide of the same metal, pressing the mixture and then submitting it to a combined reducing and sintering operation.

(2385) U. S. 1,116,450 (1914). A. Lederer (Westinghouse Lamp Co.), *Filaments.* W filaments containing C residue from the binder are treated by heating in hydrogen to remove the C.

(2386) Brit. 16,620/1914 (1915). Julius Pintsch A. G., *Tungsten Wire.* The wire consists of a single W crystal or a plurality of crystals, each of which extends through the entire length of the filament, and formed by passing the metal through a short zone of very high temperature.

(2387) Brit. 23,496/1914 (1915). Glühfadenfabrik Aarau A. G., *Ductile Tungsten.* A process for producing pure massive malleable ductile W consists of fusing the metal to a fluid mass and then rapidly cooling.

(2388) U. S. 1,123,625 (1915). O. M. Thowless, *Filament.* W powder, ZrO_2 and a binder are mixed into a paste, extruded and sintered.

(2389) U. S. 1,132,523 (1915). A. Lederer, *Manufacture of Incandescent Filaments of Metallic W or Mo for Electric Incandescent Lamps.* Powdered refractory metal and material belonging to the camphor group of aromatic substances are mixed for purposes of obtaining metal in filamentary form.

(2390) U. S. 1,135,154 (1915). F. Blau (General Electric Co.), *Removing Carbon from Tungsten.* C is removed from pressed powdered W having a C binder, by heating in N_2 and H_2.

(2391) U. S. 1,154,701 (1915). E. A. Krüger, *Process of Producing Tungsten Filaments.* A rod consisting of powdered W and a small proportion of C and boric acid is pressed, heated to approximately 1200° C. (2200° F.), then heated by electric current in H_2 stream to a temperature near the melting point, after which the product is reduced mechanically to wire.

(2392) Brit. 8,702/1915 (1916). British Thomson-Houston Co., Ltd., *Refractory Metal Tubes.* A method of preparing tubular bodies of refractory metals consists of filling a tubular mold with W or Mo metal powder, compressing it in a radial direction applied to the inner wall of the mold, and heating the mass to partially sinter it before detaching it from outer wall.

(2393) German 291,994 (1916). Julius Pintsch A. G., *Production of Filaments.* The W wire is heated over a short length so high that the crystal grows to the length of the filament.

(2394) German 293,235; 293,236 (1916). Julius Pintsch A. G., *Production of Filaments.* The W wire is heated to a temperature at which a single crystal is formed over the entire length of the filament.

(2395) U. S. 1,178,418 (1916). J. A. Scoular (Dick, Kerr & Co. Ltd.), *Filament.* W powder is mixed with a Na_2SiO_3 solution and formed into the raw filament which is sintered and dipped in HF.

(2396) U. S. 1,188,057 (1916). K. Farkas (E. J. Walscheid), *Process of Making Metallic Filaments.* Flexible metallic filaments, *e.g.* of W, are produced by passing the pressed filament of the refractory oxide through a continuously flowing current of heated H_2 surrounded by a stationary atmosphere of H_2.

(2397) U. S. 1,201,611 (1916). K. Nishimoto, *Filament.* Powdered W and a small proportion of Th are mixed, pressed and sintered in stick form, then drawn into filaments.

(2398) U. S. 1,205,080 (1916). F. Baumann (Wolfram Lampen A. G.), *Filament.* Filaments are produced from rod made by heat treating W powder and binder.

(2399) U. S. 1,206,704 (1916). H. Helfgott (General Electric Co.), *Filament.* Malleable W for wires is produced by pressing and sintering a mixture of coarse-grained and fine-grained W powder.

(2400) U. S. 1,208,629 (1916). O. Oberländer, (General Electric Co.), *Metal Filament Manufacture.* W bodies are produced from a pasty product of a halogen tungsten-compound and methylated ether or its equivalent, and evaporating resulting product to the desired consistency. Process applies also to Mo.

(2401) Brit. 106,547 (1917). J. Gray (Metallgesellschaft A. G.), *Tungsten Powder for Use in Crucibles.* A crucible of W is formed of rods held together by detachable bands or welded at joints with fused W.

(2402) German 296,191 (1917). Julius Pintsch A. G., *Production of Metal Bodies.* The products made by the method of German 291,994 (No. 2393) are worked by drawing or rolling in such a way that no change of the structure takes place.

(2403) German 297,015 (1917). Konrad Sannig & Co., *Production of Filaments.* The W powder is mixed with small quantities of C powder and boric acid, pressed and sintered.

(2404) U. S. 1,226,925 (1917). O. M. Thowless, *Filament.* Making a ductile filament entails sintering compressed refractory metal powders such as W in a mixture of dry H_2 and the vapor of refractory metal halogen salt.

(2405) U. S. 1,240,700 (1917). E. Friederich (General Electric Co.), *Tungsten Incandescent Electric Lamps.* Clouding of the bulb of W lamps is prevented by placing $Ba(ClO_3)_2$ within the bulb in such a position with respect to the W filament that $Ba(ClO_3)_2$ is sufficiently heated to give off oxygen which reacts with the W.

(2406) Brit. 113,838 (1918). M. J. Insull, *Electrical Contacts of Pure Tungsten.* A W contact has the grain of the tungsten extending perpendicularly to the contact face.

(2407) U. S. 1,256,929; 1,256,930 (1918). O. Schaller, *Filament.* Pulverized W with 2% ThO_2 is pressed into a continuous filament, and heat treated to form a long crystal.

(2408) U. S. 1,280,825 (1918). A. Pacz (General Electric Co.), *Tungsten Wire.* A process of treating drawn W wire which is subjected to the action of impurities during manufacture consists of heating it to a comparatively low temperature while in contact with a reagent which will combine with impurities.

(2409) U. S. 1,282,122 (1918). C. A. Pfanstiehl (Pfanstiehl Co.), *Process for the Production of Ductile Tungsten.* Finely powdered W is compressed to a density greater than 15.5, and the ingots are subsequently fused.

(2410) U. S. 1,284,648 (1918). F. W. Gill (General Electric Co.), *Tungsten Filament.* Improvement of product is obtained by coating a light-giving portion of the filament with a well distributed layer of inorganic halogen getter, insufficient in amount to produce discoloration of the bulb, and so thin that the life of the lamp is increased by the getter.

(2411) U. S. 1,286,089 (1918). C. A. Pfanstiehl (Pfanstiehl Co. Inc.), *Hollow Objects of Compressed Refractory Metal Powder.* A method of producing hollow articles of W powder comprises inserting into the molded powder a metal part which flows under the pressure of compression and heating of the W powder, and thereafter removing the metal part by acid.

(2412) Brit. 121,595 (1919). Westinghouse Lamp Co., *Filaments.* A method of giving a metallic filamentary material, *e.g.* W, non-sagging properties entails pre-determining a heat seasoning schedule that will cause development of crystals having considerable length, and arranged to overlap each other.

(2413) German 315,930 (1919). P. Schwarzkopf and S. Burgstaller, *Production of Bodies of Tungsten or Molybdenum.* The process comprises using a solid solution of O in the metal whereby the O content in each particle is less than in the particles of the metal oxide; this mixture is pressed and sintered in a reducing atmosphere.

(2414) U. S. 1,297,000 (1919). P. Orange, *Filaments.* Filaments are formed by reducing, sintering and working W oxide particles coated with a metallic film of an auxiliary metal.

(2415) U. S. 1,299,017 (1919). A. Pacz (General Electric Co.), *Tungsten Wire.* W wires are manufactured from a mixture of pure W powders derived from different chemical compounds.

(2416) U. S. 1,318,452 (1919). F. G. Keyes (Cooper Hewitt Electric Co.), *Crucible.* A pure W crucible, which consists of a porous W cup, can be filled with W oxide and heated by electrical resistance until the oxide melts.

(2417) U. S. 1,323,623 (1919). K. Farkas, *Filaments.* Wire for filaments is drawn from heated bar of pressed W powder.

(2418) German 322,552 (1920). Dick, Kerr & Co. Ltd., *Production of Filaments.* Addition to German 272,347 (No. 1606). The filaments produced from W powder and Na_2SiO_3 are agitated with a solution of HF after sintering.

(2419) German 325,464 (1920). H. Leiser, *Method of Producing Pressed Shaped Bodies.* Method of producing shaped bodies of W, Mo or Cr in the crystalline state comprises mixing them with an amorphous powder and heating this mixture to the temperature at which the amorphous metal is converted to the crystalline state.

(2420) U. S. 1,363,162 (1920). R. E. Myers (Westinghouse Lamp Co.), *Filament.* Offsetting of W filaments is prevented by the addition of CaO and MgO.

(2421) Brit. 163,014 (1922). Patent-Treuhand-Ges. für Elektrische Glühlampen, *Drawing of Tungsten Wires.* Before sintering, cross section zones are introduced into the ingot which differ from one another in chemical or physical properties and composition of the constituents, resulting in drawn wires in which longitudinal crystals predominate.

(2422) Brit. 174,714 (1922). General Electric Co. Ltd. and F. S. Goucher, *Tungsten Filaments for Electric Incandescent Lamps.* The manufacture of W filaments consists of annealing a wire, applying a strain to the wire and passing it through a zone of steep temperature gradient whose maximum temperature is very high.

(2423) Brit. 186,497 (1922). General Electric Co. Ltd. and C. J. Smithells, *Tungsten.* W filaments are produced by the addition of thoria or silica and alkali metal.

(2424) Brit. 188,706 (1922). Siemens Bros. & Co. and W. H. Le Maréchal, *Tungsten.* W for lamp filaments is produced with the aid of ThO_2 and boric acid additions.

(2425) U. S. 1,410,499 (1922). A. Pacz (General Electric Co.), *Tungsten Wire.* A process of producing non-sagging and non-offsetting W filaments consists of intimately associating finely divided W with a volatizing material during sintering.

(2426) Brit. 202,001 (1923). British Thomson-Houston Co., *Method of Making Tungsten Wires.* A method of producing W filaments entails the addition of two alkalies, one being K, Ru or Ce to the W powder.

(2427) German 382,145 (1923). Patent-Treuhand-Ges. für elektrische Glühlampen, *Production of Tungsten Wires.* Longitudinal zones of different physical or chemical properties are formed when the pressed body is worked mechanically.

(2428) German 382,515 (1923). Patent-Treuhand-Ges. für elektrische Glühlampen, *Production of Tungsten Wire.* The W powder is mixed with an auxiliary metal

which contains some silicic acid and potash, which are vaporized during the sintering, and affect the growth of the grains.

(2429) Swiss 100,240 (1923). Westinghouse Lamp Co., *Production of Coherent Bodies of Refractory Metals.* Powdered metals such as W or Mo, or their alloys, are first slowly heated *in vacuo*, to drive off the gases, and then the temperature is raised for sintering the powder.

(2430) U. S. 1,461,117; 1,461,118 (1923). R. D. Hall (Westinghouse Lamp Co.), *Filament.* A non-sag W filament is made by adding thoria or alumina compounds to the W powder at the start of the process, by which the crystalline formation may be controlled.

(2431) U. S. 1,468,073 (1923). A. Pacz, (General Electric Co.), *Tungsten Wire.* Production of filaments comprises heating to a high temperature a mixture of W, Si compound, and a reducing agent, pressing this powder into slugs and subsequently heating and mechanically working.

(2432) U. S. 1,469,761 (1923). J. A. Yunck, *Ingot of Refractory Metal.* The process consists of packing W powder in a cylinder of Cu, and closing the open ends with plugs, swaging down this cartridge, and heating the formed rod in a C tube until the Cu envelope is vaporized and the W particles are sintered together.

(2433) Brit. 209,028 (1924). General Electric Co., *Electrodes for Tungsten Arc Lamps.* The manufacture of electrodes for W arc lamps comprises pressing W powder and sintering the body as a preliminary step, mechanically working it, and finally sintering each to a carrier stem of W by heating it to white heat.

(2434) German 391,760 (1924). Patent-Treuhand-Ges. für elektrische Glühlampen, *Tungsten Filament.* The W powder is mixed with 0.1-1% Fe, then pressed and sintered, so that the Fe evaporates.

(2435) German 391,874 (1924). Patent-Treuhand-Ges. für elektrische Glühlampen, *Production of Single Crystal Bars of Tungsten.* The pressing is heated to a temperature near the melting point and for a period sufficient to effect the formation of a single crystal.

(2436) U. S. 1,500,789 (1924). E. Aoyagi, *Filament.* A ductile filament is produced by heating rods of refractory metal (*e.g.*, W) powder, and hanging them vertically until the rod elongates to proper length.

(2437) U. S. 1,508,241 (1924). A. Pacz (General Electric Co.), *Filament.* A non-sagging W filament is derived from an intimate mixture of W and a compound containing the oxide of Ta or Cb.

(2438) Austrian 100,048 (1925). Patent-Treuhand-Ges. für elektrische Glühlampen, *Production of Tungsten Wire.* W powder is mixed with alkali silicate which vaporizes below the sintering temperature, to produce a rapid growth of the W grains during sintering.

(2439) Brit. 214,662 (1925). General Electric Co. Ltd., *Manufacture of Tungsten Wire.* The method entails compressing pure WO_3 before reduction into bars, which are subjected to a fusion treatment.

(2440) Brit. 215,347; 215,348 (1925). British Thomson-Houston Co. Ltd., *Manufacture of Sintered Tungsten Filaments.* Powdered W is incorporated with 0.5% Th and 0.25% Cu or 0.3% Be nitride, pressed and sintered.

(2441) Brit. 216,124 (1925). N. V. Philips' Gloeilampenfabrieken, *Structure of Tungsten Wire.* The method is characterized by the use of an alkali salt of a Cr-O or Mn-O compound as an addition agent to W powder.

(2442) Brit. 235,213 (1925). N. V. Philips' Gloeilampenfabrieken, *Tungsten Rods.* Rods of W are formed by sintering the powder under high pressure to produce crystals having dimensions of 1 cm. average diameter or more.

(2443) Brit. 239,742 (1925). A. S. Cachemaille, *Structure of Tungsten Wire.* The method entails the use of alkalies and Li_2O with the W powder.

(2444) Brit. 245,654 (1925). Cycle Corp., *Dies for Wire-Drawing.* The dies are made by fusing W associated with a hardening agent and consolidating it with a metal supporting body.

(2445) Swiss 109,385 (1925). N. V. Philips' Gloeilampenfabrieken, *Production of Filaments of Tungsten.* W powder is mixed with an alkali salt of an O compound of Cr or Mn, so that the product contains only 0.1% of these compounds, to inhibit recrystallization and to direct grain growth.

(2446) Swiss 109,791 (1925). Licht A. G., *Production of Ductile Bars and Wires of Tungsten or Molybdenum.* The metal powder is pressed, moved forward and sintered in a continuous operation.

(2447) U. S. 1,546,899 (1925). R. Jacoby (General Electric Co.), *Method and Apparatus for Transforming Crystalline Structure of Drawn Tungsten Wire.* Enlarging crystals is effected by passing them through a high temperature zone.

(2448) U. S. 1,552,122 (1925). A. De Graaff (General Electric Co.), *Manufacture of Tungsten Powder.* W powder for filaments is produced by forming silicotungstic acid, removing the by-product of the reaction, pulverizing and reducing with H_2 to form metallic W containing SiO_2.

(2449) U. S. 1,558,000 (1925). H. M. Fernberger (General Electric Co.), *Tungsten Wire.* Crystals of a double salt of W, containing NH_4 and K, are converted to WO_3, then to W metal which is pressed, sintered and worked into filaments.

(2450) U. S. 1,559,799 (1925). C. J. Smithells (General Electric Co. Ltd.), *Structure of Tungsten Wire.* The addition of ThO_2 and alkalies influences the grain structure and grain size of the W filament.

(2451) U. S. 1,562,202 (1925). H. Boving (Western Electric Co.), *Filament.* A filament alloy is made from powdered W, exposed to the vapor of Ba.

(2452) U. S. 1,601,931 (1926). A. E. Van Arkel (General Electric Co.), *Filaments.* To increase the cross section of a W filament, it is placed in WCl_3 vapor from which W dissociates and settles on the crystal; powdered W is used to produce the vapor.

(2453) U. S. 1,602,525; 1,602,526; 1,602,527 (1926). W. B. Gero (Westinghouse Lamp Co.), *Filaments.* W powder for forming filaments of oriented crystal structure is made by mixing with WO_3 a soluble salt of alkali-earth metals and reducing the mixture.

(2454) German 452,865 (1927). N. V. Philips' Gloeilampenfabrieken, *Wire from Tungsten.* The W powder is mixed with 0.1 -3% HfO_2 to control recrystallization and to direct grain growth during sintering, swaging, and drawing.

(2455) U. S. 1,635,055 (1927). A. Pacz (General Electric Co.), *Tungsten Filament.* ZrO_2 is mixed with Mg and heated; 1% of the product of the reduction is further mixed with W and SiO_2, reduced and worked.

(2456) U. S. 1,648,679 (1927). G. R. Fonda (General Electric Co.), *Filament.* Less than 1% of B is added to W powder before sintering, decreasing the tendency of the helical filament to sag.

(2457) U. S. 1,650,631 (1927). F. Koref and H. Alterthum (General Electric Co.), *Tungsten Wire.* A large W crystal is formed by sintering powdered W which is worked into a wire.

(2458) Brit. 292,997 (1928). General Electric Co. Ltd., *Solid Tungsten Powder Bodies.* A method of manufacturing solid bodies of high density is claimed, in which metal powders such as W are sintered to form a porous body, then compressed by members which produce no resistance to lateral expansion.

(2459) U. S. 1,662,027 (1928). A. De Graaff (General Electric Co.), *Tungsten Wire.* Pure tungstic acid is mixed with 0.6% of $K_2Cr_2O_7$ and reduced to a very fine powder, which is then pressed and sintered.

(2460) U. S. 1,675,486 (1928). C. G. Fink, *Tungsten Wire.* The production of W wire is characterized by the addition of Zr and Cu to the W.

(2461) U. S. 1,704,256 (1929). C. F. Lorenz (Westinghouse Lamp Co.), *Refractory Ware such as Crucible.* The bodies are produced by sintering W metal powder to a metallic wool in a mold; the wool is claimed to give added strength to the vessel.

(2462) U. S. 1,721,383 (1929). G. R. Fonda (General Electric Co.), *Filament.* Powdered W is mixed with 0.5% Th and 0.3% B nitride.

(2463) U. S. 1,728,814 (1929). J. A. Van Liempt (General Electric Co.), *Filaments.* Unicrystalline wire is formed in a coil and treated according to U. S. 1,601,931 (No. 2452).

(2464) U. S. 1,733,752 (1929). J. H. Ramage (Westinghouse Lamp Co.), *Filament.* A non-sag single crystal filament is formed from a pressed slug of pure W powder passed through a very hot zone at a very slow rate of speed in vacuum.

(2465) Brit. 337,160 (1930). Metallgesellschaft A. G. and A. Pacz, *Manufacture of Tungsten.* W powder is mixed with a volatile metal which forms with O an unstable compound at the sintering temperature.

(2466) U. S. 1,752,877 (1930). H. Alterthum (General Electric Co.), *Macrocrystalline Ingots of Tungsten.* A body of pressed W powder metal is heated for a considerable time (*e.g.* 30 min. or longer) at a temperature near the melting point in dried H_2 with small amount of oxidizing agent (*e.g.* trace H_2O).

(2467) French 703,960 (1931). Comp. Francaise Pour L'Exploitation Des Procedés Thomson-Houston, *Refractory Metal Composition.* ThO_2 is added to W to prevent grain growth during sintering.

(2468) Brit. 384,309 (1932). Vereinigte Glühlampen und Elektrizitäts A. G., *Process for the Production of Large Crystalline Metallic Bodies.* Blocks, bars, sheets, wires, and incandescent bodies are produced from refractory materials like W, Mo, Re, plus additive materials like phosphates, silicates, titanates, borates, etc.

(2469) U. S. 1,857,219 (1932). C. J. Smithells (General Electric Co. Ltd.), *Refractory Metal Bodies.* The method comprises sintering molded W powder to bodies at a temperature slightly below its melting point in an atmosphere containing Na vapors.

(2470) U. S. 1,896,606 (1933). C. F. W. Bates (Ohio Instrument Manufacturing Co.), *Filament.* A W filament is produced by mixing W and Ag, compacting, and sintering to volatilize all the Ag.

(2471) French 764,289 (1934). A. Pacz, *Reaction Product of Gallic Acid and Tungsten Compound. Cf.:* U. S. 2,078,609 (No. 2480).

(2472) U. S. 1,965,222 (1934). F. H. Driggs (Westinghouse Lamp Co.), *Tungsten Wire.* KCl is used as an addition agent for W powder.

(2473) Brit. 427,757 (1935). Y. Sakakura, *Incandescent Lamp Filaments.* Sintered W is worked to filament size.

(2474) Hung. 113,112 (1935). Egyesult Izzolampa Es Villamossagi R. T., *Powdered Tungsten Mixture Especially for Making Filaments for Incandescent Lamps.* W powder is mixed with alkaline silicate, pressed, sintered, swaged, and drawn to wire.

(2475) U. S. 2,018,470 (1935). S. Ruben (Sirian Lamp Co.), *Electric Incandescent Lamp Filaments.* W or Mo wire filaments are coated with a mixture of 4 parts of 99/1 thoria/ceria and 1 part of boric acid.

(2476) U. S. 2,038,402 (1936). P. P. Alexander (General Electric Co.), *Filaments.* Filaments of W powder are prepared by reducing halides of W.

(2477) U. S. 2,076,381 (1937). T. Millner and P. Tury (General Electric Co.), *Process for Manufacturing Metal Bodies.* W bodies of large crystal structure are produced by molding a blank of finely divided pure W, sintering in H_2 and heating to 2000° C. (3630° F.) in H_2 mixed with water vapor until crystallization occurs.

(2478) U. S. 2,077,873 (1937). C. H. Braselton (Sirian Wire & Contact Co.), *Tungst Ingot.* A filament ingot is formed by reducing a dehydrated powder of WO_3 in H_2 together with an alkali metal tungstate, then compacting the product and baking it, thereby volatilizing the residual alkaline compound.

(2479) U. S. 2,078,182 (1937). A. E. MacFarland (Sirian Wire & Contact Co.), *Structure of Tungsten Wire.* Potassium fluotitanate and alkalies are used to control the grain size of the W.

(2480) U. S. 2,078,609 (1937). A. Pacz, *Reaction Product of Gallic Acid and Tungsten Compound.* A binder for metal powders is made by forming a reaction product of gallic acid with a soluble tungstate salt, whereby a highly plastic, organic, W product is produced.

(2481) Austrian 154,322 (1938). J. Salpeter (Allgemeine Glühlampenfabriken A. G.), *Electric Lamp Filament. Cf.:* German 675,140 (No. 2488).

(2482) Brit. 481,964 (1938). Allgemeine Glühlampenfabriken A. G., *Heat-Treating Tungsten Wire.* A coiled filament is subjected for half a second to heat treatment at a temperature below the melting point of W but not less than 2800° C. (5070° F.).

(2483) U. S. 2,109,762 (1938). S. Abe and T. Nagai (Kabushiki Kaisha Kawanishi Kikai Seisakujo), *Filament.* A non-sag filament is produced from a mixture of pure W particles and oxide coated W particles, which is sintered into an ingot containing large, pure W particles.

(2484) U. S. 2,114,426 (1938). C. A. Laise, *Metal Powder for Filaments.* The powder consists of a mixture of fine and coarser particles of W coated with a thin film of alkaline tungstate.

(2485) Brit. 498,367 (1939). General Electric Co. Ltd. and C. J. Smithells, *Sintering of Refractory Metal Powders.* Compacted W or Mo powder is protected from oxidation during sintering by the presence of C or like solid material, yielding CO when heated in air.

(2486) Brit. 505,792 (1939). Aktiebolaget Hammarbylampan, *Electric Lamp Filament.* An electric lamp filament is composed of a core of granulated W with an electrolytic coating of fine crystalline grains of W, Ta, or Re that remain, even after heating the core to a high temperature, so that the grains show a varying crystallographic orientation.

(2487) French 835,869 (1939). Électro-Soudure S. A., *Conductive Refractory Body.* Its production consists of ball-milling, with balls of porcelain, a mixture of 55% lubricated fine Mo powder and 45% silicate, till the silicate has such a fineness that it completely adsorbs the Mo, after which this mass is sintered.

(2488) German 675,140 (1939). Allgemeine Glühlampenfabriken A. G., *Filament.* A W filament without sag is fixed on a carrier which is connected with an electric current and which is moved during the recrystallization in the direction of gravity with such an acceleration that the action of the gravity is accentuated to shorten the time of recrystallization.

(2489) German 692,461 (1940). Vereinigte Glühlampen & Elektrizitäts A. G., *Tungsten Bodies Consisting of Single Crystals.* Tungstic acid is reduced with H_2 to produce W powder, which is pressed and heated to 1300° C. (2370° F.), then sintered by means of alternating current of low voltage and high current density in H_2 up to 2200° C. (3990° F.); the formation of a single crystal is effected by saturating the H_2 with steam for one minute.

(2490) U. S. 2,215,645 (1940). C. V. Iredell and T. J. Hankins (Westinghouse Electric & Mfg. Co.), *Method and Apparatus for Treating Tungsten.* The ingot used for the production of W filaments is electrically heated in H_2, containing some proportion of water vapor.

(2491) U. S. 2,285,293 (1942). W. E. Mansfield (Cleveland Tungsten Inc.), *Tungsten for Contacts.* The contact is fabricated from W having a dispersed grain structure, in which the W grains are approximately equal to, or substantially larger than, the W grains in fabricated ductile W, and in which there is no line of cleavage in any direction.

(2492) U. S. 2,360,707 (1944). J. E. Mouromtseff and G. M. Dinnick (Westinghouse Electric & Mfg. Co.), *Electron Discharge Device.* An electrostatic shield member for electron discharge device consists of W or Mo metal.

(2493) German 750,464 (1945). E. Willner and P. Sidow, *Seamless Thin-Walled Tungsten Tubes.* Small W tubes for use as cathodes are made by applying W powder to a MgO rod and presintering it; then the MgO rod is dissolved and the product is sintered by resistance heating.

(2494) U. S. 2,373,405 (1945). R. Lowit (Callite Tungsten Corp.), *Process of Making Seamless Hollow Bodies of Refractory Metals.* The process involves pressing Mo powder in a die around a borosilicate glass core, heating it to a temperature just below the melting point of Mo to sinter the powder, and melting out the core, inserting a metal rod, and swaging down the whole body.

(2495) Brit. 601,200 (1948). Philips Lamps Ltd., *Incandescent Cathode for Discharge Tube.* A cathode is built up from W wires arranged in zigzag fashion, giving a hollow prism structure; the wires are bonded at their contacts with sintered Ni.

(2496) Brit. Appl. 407/48 (1948). Westinghouse Electric International Co., *Method of Producing Molybdenum.* Easily machinable Mo is produced by working the material with intermediate annealings at different temperatures in moist H_2 to give grains with a length-width ratio of less than 4:1.

(2497) Brit. Appl. 20068/48 (1948). American Electro Metal Corp., *Blades and Elements for Gas Turbines.* Pure Mo powder is compacted and presintered in very dry H_2, shaped either cold or hot by coining, and finally sintered. The tensile strength is about 80,000 psi at 800° C. (1470° F.). Blades of W can be prepared similarly.

(2498) Swiss 248,874 (1948). M. Gloor and F. Koref, *Tungsten Objects of Higher Density.* The bodies are produced by boring the W rod, heating it, and working it while hot in such a way that elongation parallel to the bore takes place.

(2499) U. S. 2,439,913 (1948). J. A. M. Van Liempt (General Electric Co.), *Method of Treating Coiled Tungsten Filaments.* Vibration resistance and extensibility of a W filament in the direction of the axis can be produced in a non-sagging wire by effecting advanced lattice restoration prior to recrystallization.

(2500) Brit. 609,278 (1949). Westinghouse Electric International Co., *Refractory Metal Tubes.* Mo tubes, for use as gun barrel liners, are made by winding Mo wire on a mandrel, which is drilled out, and filling the gaps left externally between turns with brazing powder.

(2501) Brit. 609,902 (1949). Siemens Electric Lamps & Supplies Ltd. and W. G. Creasy, *Tungsten Filament.* Ductile W is obtained by mixing a thoriated and a silicated powder in such proportions that the mixture contains 0.75% ThO_2 and 0.5% SiO_2.

(2502) Brit. Appl. 8108/49; 9131/49 (1949). American Electro Metal Corp., *Coated Metal Article.* Sintered Mo blades are coated with Al, heat treated to form partially a Mo-Al alloy and partially a layer of Al, and finally oxidized to give an alumina top coating. An apparatus for producing the coatings with Al or Ce by fused salt electrolysis is described.

(2503) U. S. 2,489,912 (1949). W. C. Lilliendahl (Westinghouse Electric Corp.), *Method of Producing Tungsten.* The recrystallization temperature of pure W is increased by incorporating .020% to about .035% Fe. This is done by precipitating tungstic acid, and adding an Fe compound in a water solution. The acid is reduced to metallic W and the latter is compacted to coherent form.

B. Tantalum and Columbium

(2504) U. S. 817,732 (1906). W. v. Bolton (Siemens & Halske A. G.), *Electric Lamp.* An incandescing body for electric lamps is produced from pure, powdered Ta to which paraffin is added as binder.

(2505) U. S. 817,733 (1906). W. v. Bolton (Siemens & Halske A. G.), *Incandescing Body for Electric Lamps.* An incandescing body is produced from Ta by passing an electric current through the compressed powders of Ta compounds.

(2506) U. S. 891,223 (1908). W. v. Bolton (Siemens & Halske A. G.), *Electric Lamp.* A heated body produced from Ta powder is drawn to a filament.

(2507) U. S. 905,402 (1908). W. v. Bolton (Siemens & Halske A. G.), *Filaments.* Filaments are made from refractory metal powders such as Ta, to which has been added C, which is subsequently removed by heating the filament in acetic acid vapors.

(2508) Brit. 358,531 (1931). Fansteel Products Corp., *Process for Removing Carbon Impurities from Refractory Metals, Particularly Tantalum.* Refractory metals such as Ta and containing C are mixed with oxides of Mg, Be, Li, pressed and sintered in vacuum to remove C.

(2509) U. S. 2,362,468 (1944). R. U. Clark (Fansteel Metallurgic Co.), *Getter.* A getter for cleaning up residual gas in vacuum devices uses Cb or Ta sintered to a porous body.

C. High-Melting Precious Metals (Platinum-Group Metals)

(2510) U. S. 976,526; 976,527; 976,528 (1910). C. Auer v. Welsbach (Welsbach Light Co.), *Manufacture of Electric Filaments.* Os powder is mixed with syrup of sugar to make a stiff paste which is pressed through a die; after drying the filament is heated to drive off the volatile constituents, then heated by an electric arc, to remove C without oxidizing the Os particles, which are sintered and cemented at a temperature above the melting point of Pt, after which the filament is coated with ThO_2.

(2511) U. S. 1,109,886 (1914). C. Auer v. Welsbach (Welsbach Light Co.), *Filaments.* Pt wire is coated with powdered Os in an organic binder.

(2512) U. S. 1,109,887 (1914). C. Auer v. Welsbach (Welsbach Light Co.), *Filament.* The filament contains Os and an oxide of a rare metal, *e.g.* ThO_2, applied to the filament to form an unreduced coating.

(2513) U. S. 1,109,888 (1914). C. Auer v. Welsbach (Welsbach Light Co.), *Filaments.* The filaments are produced from a paste of Os, ZrO_2 and C which produces an alloy of Zr and Os.

(2514) Brit. 519,702 (1940). Goldsmith Bros. Smelting & Refining Co., *Tips of High Melting Point.* Pt-group metals are formed into shaped objects of homoheteroaxial crystal structure by using high pressure followed by sintering.

(2515) U. S. 2,206,616 (1940). A. R. Devereux and C. Pfanstiehl, *Osmium Composition.* Os compositions are produced by mixing, pressing and heating powdered Os and a lower melting point metal.

(2516) U. S. 2,254,975 (1941). M. R. Pickus (Parker Pen Co.), *Pen Tip.* The tip is composed of sintered powdered Pt carbide and Au.

(2517) U. S. 2,312,324 (1943). A. R. Devereux (Goldsmith Bros. Smelting & Refining Co.), *Osmium Composition.* An Os alloy is produced by pressing and sintering Os and Pt powders.

(2518) U. S. 2,328,580 (1943). M. R. Pickus (Parker Pen Co.), *Pen Point.* The tip is made of powdered Ru and Pt.

(2519) Brit. 578,956 (1946). Lodge Plugs Ltd., *Platinum or Allied Metals.* Mixed powders of Pt, Ir, Pd and Cr_2O_3 are compacted and sintered.

(2520) U. S. 2,394,727 (1946). G. F. Taylor (Carboloy Co.), *Method for Making Small Metallic Iridium Spheres.* The method comprises compressing the powdered metal into a compact mass, placing it on a perforated glass-like support and heating the support and mass at a temperature at which the material will fuse and sink into, but not all the way through the perforations of the glass-like support.

(2521) U. S. 2,406,172 (1946). C. J. Smithells (Baker and Co.), *Precious Metals for Electric Articles.* Finely divided Pt, Ir or Pd is compacted and sintered to form electric articles.

(2522) U. S. 2,432,888 (1947). F. R. Hensel (P. R. Mallory & Co.), *Platinum Base Alloy For Spark Plug Electrodes.* An alloy is composed of 0.05-3% Th, 5-10% Mo, balance Pt; the Th serves to inhibit grain growth in the alloy.

(2523) French 941,701 (1948). Baker Platinum Ltd., *Articles of Platinum or Its Alloys.* The fibrous structure in worked compacts is maintained by incorporating ThO_2, ZrO_2, or BaO in the powder.

(2524) U. S. 2,476,208 (1949). A. Beresford (International Nickel Co., Inc.), *Sintered Precious Metal Product.* Invention relates to improvements in metal alloy electrodes for use in spark plugs, *e.g.*, Pt-W, Pt-Rh, etc. Electrodes highly resistant to recrystallization and to penetration of Pb compounds are produced when powders of these metals are compacted, sintered, forged and severely cold drawn to a fibrous structure.

D. Rare Refractory and Semi-Refractory Metals and Semi-Metals

(2525) German 234,220 (1911). Soc. Francaise D'Incandescence par le Gaz, *Production of Filaments.* Filaments consisting of Ti or V oxide, but free of C, are heated in an atmosphere containing H_2 and NH_3 to white heat by passage of current through them.

(2526) U. S. 1,071,488 (1913). G. Weintraub and H. Rush (General Electric Co.), *Process for Sintering Refractory Materials.* A process for sintering powdered B into coherent rods comprises confining B by an inert material of high electric insulating value and impressing a potential great enough to break down its resistance, progressively increasing the wattage, while maintaining the pressure upon the B until it is sintered.

(2527) Brit. 230,865 (1925). Westinghouse Lamp Co., H. C. Rentschler and J. W. Marden, *Method of Preparing Uranium in a Coherent Mass. Cf.:* U. S. 1,648,962 (No. 2530).

(2528) Brit. 258,024 (1926). A. S. Cachemaille, *Ductile Chromium from Powder.* Ductile Cr is produced by slowly heating a bar of compressed powder in inert gas or high vacuum for sintering till particles coalesce and bar can be worked at a red heat.

(2529) Brit. 285,571 (1926). General Electric Co. Ltd. and C. J. Smithells, *Chromium Powder Bodies.* Manufacture of coherent bodies of Cr comprises agglomerating the pure powder into bars and sintering them at 1500° C. (2730° F.) in H_2.

(2530) U. S. 1,648,962 (1927). H. C. Rentschler and J. W. Marden (Westinghouse Lamp Co.), *Method of Preparing Uranium in a Coherent Mass.* The method consists of pressing U powder into a compact body in a closed vessel, withdrawing the vessel into an atmosphere of inert gas, heat-treating the body to white heat to expel all volatile impurities, and finally sintering.

(2531) U. S. 1,685,915 (1928). W. B. Gero (Westinghouse Lamp Co.), *Fabrication of Metallic Thorium.* Compacting the rare refractory metal, *e.g.* Th, entails encasing the Th with a soft metal, *e.g.* Pb, and subjecting it in the coherent state to pressure.

(2532) German 488,472 (1929). Westinghouse Lamp Co., *Production of Ductile Chromium.* Cr powder is pressed and heated under high vacuum to remove gases, then to higher temperature for sintering, until the melting point is nearly reached; after cooling, the bar is worked.

(2533) U. S. 1,719,975 (1929). W. B. Gero (Westinghouse Lamp Co.), *Annealed Thorium.* A swaged Th rod for filaments is annealed in a closed bomb, wherein it is packed in powdered Th and W which react with the impurities.

(2534) U. S. 1,728,942 (1929). J. W. Marden (Westinghouse Lamp Co.), *Uranium Filament.* U is alloyed with Zn to permit powdering, and heat treated *in vacuo* to fuse the U into a coherent form while the Zn evaporates at low temperatures.

(2535) U. S. 1,760,367 (1930). J. W. Marden and M. N. Rich (Westinghouse Lamp Co.), *Ductile Chromium and Method of Producing Same.* Producing malleable Cr masses consists of compacting metal powder of substantial purity and heating in inert atmosphere to drive off the gas content, and subsequently consolidating the ingot by subjecting it to a temperature somewhat below the melting point.

(2536) U. S. 1,760,413 (1930). W. P. Kiernan (Westinghouse Lamp Co.), *Articles of Zirconium.* Powdered Zr is compacted and heated in high vacuum to effect degasification. It is then sintered in high vacuum and subjected to mechanical deformation above 800° C. (1470° F.).

(2537) U. S. 1,829,756 (1931). W. Noddack, (Siemens & Halske A. G.), *Body of Rhenium.* Rh is used to make incandescing bodies by sintering the powder with a binding agent.

(2538) Brit. 384,309 (1932). Vereinigte Glühlampen und Elektrizitäts A. G., *Crystalline Metallic Bodies.* Invention relates to obtaining coherent masses from powdered metals, *e.g.* Re.

(2539) U. S. 1,854,970 (1932). C. Agte (General Electric Co.), *Lamp Filaments.* The bodies consist of a core containing Rh and a coating of TaC.

(2540) U. S. 2,299,871 (1942). C. Baird (Crowbalt Inc.), *Chromium Alloys For Cutting Tools.* A chromium alloy consists of 15-35% Cr; 10-30% W or Mo; 1-4% C; .01-5% V; .01-4% Zr or Ti; .01-5% Fe; plus 20-60% of a non-ferrous matrix-forming metal such as Co or Ni or both.

(2541) French 881,290 (1943). Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H., *Pill for Absorption of Gases.* The getter consists of an alkali-earth and Mg mixed with powdered Ce, Ti or Zr.

(2542) U. S. 2,391,458 (1945). F. R. Hensel (P. R. Mallory & Co.), *Spark Gap Electrode.* The electrode has a body of a refractory metal and integral therewith a working surface layer of Rh.

(2543) French 920,631 (1947). Westinghouse Electric & Mfg. Corp., *Manufacture of Thorium.* The powder is made by fusing the ThO_2 with 100% excess of Ca in A atmosphere, then leaching it with dilute acetic acid and diluted glacial acetic acid; the powder is hot-pressed at 18 tsi at 1200-1400° C. (2190-2550° F.) in vacuum.

(2544) U. S. 2,453,896 (1948). R. S. Dean (Chicago Development Co.), *Treatment of Titanium.* A hard, tough and adherent coating on objects of Ti is produced by subjecting it to the action of a molten alkali metal cyanide.

(2545) U. S. 2,463,404 (1949). D. McKinley (E. I. du Pont de Nemours & Co.), *Process for the Production of Boron Articles.* The process comprises compacting pure B powder, heating same in preshaped form on a BeO support to a temperature between about 1800 to 2000° C. (3270-3630° F.) in an atmosphere of H_2 and then continuing the heating to effect sintering under sub-atmospheric pressure.

E. Refractory Metal Alloys and Composites

(2546) U. S. 735,293 (1903). E. Polte, *Process of Making Articles of Tungsten and Lead.* A process for the production of solid articles from purified W and Pb consists of forming together the particles of the metals in pulverulent form and pressing into shape.

(2547) German 149,440 (1904). E. Polte, *Production of Bodies of Tungsten and Lead.* W and Pb powder are mixed in ball mills and pressed.

(2548) U. S. 817,734 (1906). W. v. Bolton (Siemens & Halske A. G.), *Incandescing Body for Electric Lamps.* The body is composed of powdered alloy of V.

(2549) German 204,612 (1908). H. Kuzel, *Support for Filaments.* It consists of a refractory material in the form of a very fine powder which is mixed with the same metal powder as used for the filament, *e.g.* W, the mixture being formed and sintered.

(2550) Brit. 15,586/1911 (1912). British Thomson-Houston Co. Ltd., *Bodies of Tungsten.* A method of improving the mechanical properties of bodies of W consists of subjecting the body to a high temperature in the presence of metallic carbides, *e.g.*, CaC_2.

(2551) German 251,262 (1912). H. Leiber, *Production of an Alloy of Tungsten and Lead.* The metal powders are sprayed out of nozzles, mixed, compacted and alloyed by heating.

(2552) U. S. 1,016,804 (1912). H. Weber, *Filaments.* Finely divided W and pulverized Te are alloyed to form a tough filament.

(2553) U. S. 1,167,827 (1916). H. Kaiser, *Alloys of High-Melting Metals.* Mixtures of Cr, V, Cb, Ta, Os, Ru, Zr, Th and W plus 1% of a metal of the Pt-group are pressed and sintered.

(2554) U. S. 1,223,322 (1917). C. L. Gebauer, *Process of Producing Metal Bodies.* The method comprises molding finely disintegrated metals or mixtures of metal powders, such as W and Ag, Au or Pt, or Mn and Cu, Ag or Ni, under great pressure, and thereafter welding the constituents together by heat, the temperature being below that required to fuse the most refractory constituent.

(2555) U. S. 1,236,384 (1917). F. A. Fahrenwald (Dedicated to Government of U. S. A.), *Alloy of Tungsten and Molybdenum.* An alloy of W and Mo is produced by compacting a powdered mixture, sintering, forging and mechanically cold working.

(2556) Brit. 113,830 (1918). British Thomson-Houston Co., Ltd., *Wire-Drawing Dies from Powdered Tungsten.* A metal die for wire drawing comprises a perforated block of W consolidated with iron into a dense coherent block.

(2557) German 304,551 (1918). G. Fuchs, *Alloys of Tungsten from Powders.* W is alloyed with noble metals, which in turn are alloyed with powdered Ni, Fe, and Al.

(2558) German 307,764 (1918). G. Fuchs and A. Kopietz, *Refractory Metal Alloy.* A W-Fe alloy contains 55% W, 35% Fe, 5% Ti, 2% Ce and 3% C.

(2559) U. S. 1,268,495 (1918). H. K. Sandell (H. S. Mills), *Tungsten-Nickel Composition.* The alloy contains more than 50% Ni and less than 50% W and 3% C.

(2560) Brit. 121,596 (1919). Westinghouse Lamp Co., *Filaments.* Refractory metal powder is mixed with 2-7% by volume (2.5-10% by weight) of Ag and 0.1-0.4% by volume (0.05-0.2% by weight) of ThO_2 to control the grain growth.

(2561) U. S. 1,308,907 (1919). F. G. Keyes (Cooper Hewitt Electric Co.), *Manufacture of Tungsten-Molybdenum Alloy.* WO_3 and MoO_3 are ground mixed and reduced in H_2; the coarseness of the mixture depends on the speed of the gas stream. The alloy with 20% Mo is mixed with a little water and molded under pressure.

(2562) U. S. 1,315,859 (1919). C. A. Pfanstiehl (Pfanstiehl Co.), *Compressed Tungsten Powder Mixture.* Malleable W articles are produced by compressing a powder mixture of W, Cu and Ni to a density of more than 15 and having strength equal to blackboard chalk. The alloy is then produced by sintering.

(2563) U. S. 1,346,192 (1920). C. L. Gebauer, *Composition of Matter.* A non-homogeneous mixture is composed of mutually insoluble metals, one of which is a refractory metal and the other a noble metal, wherein each refractory particle is cast within a shell of noble metal.

(2564) Brit. 162,907 (1921). British Thomson-Houston Co., Ltd., *Tungsten Alloy with Zirconium for Lamp Filaments.* The filament is produced by sintering together Zr mixed with W to which SiO_2 is added.

(2565) U. S. 1,377,982 (1921). F. G. Keyes (Cooper-Hewitt Electric Co.), *Manufacture of Molybdenum-Tungsten Alloy.* A molded bar of the two metals in powder form is dried, heated to 1200° C. (2190° F.) and cooled in H_2, afterwards heated by passing an electric current through the bar until it has attained the melting temperature of Mo.

(2566) U. S. 1,418,081 (1922). C. A. Laise, *Alloy and Preparation of Same for Contact Bodies and Ignition Points.* The alloy contains 87-97% by weight of W, 10-3% Mo, and not more than 1% V.

(2567) U. S. 1,423,338 (1922). C. A. Laise (General Electric Co.), *Alloy and Method of Producing Same.* The alloy comprises W, Au and V with W predominating and V about 0.1% by weight.

(2568) U. S. 1,477,797 (1923). N. H. Adams (General Electric Co.), *Wear-Resisting Body from Refractory Metal Composite.* A wear-resisting body, *e.g.* a bearing, is made of an intimate mixture of 90% W and 10% Cu which is pressed and sintered at 1600° C. (2910° F.) to form a machinable article.

(2569) U. S. 1,486,214 (1924). G. F. Yessler, *Composite Refractory Body.* The body contains 98.78% W, 0.37% Fe, 0.32% Si, 0.42% Th, 0.128% O, and 0.27% Ca.

(2570) U. S. 1,496,457 (1924). G. R. Fonda (General Electric Co.), *Filament.* The filament is composed of W powder with 1% Fe powder, to form an alloy capable of operating at 2100° C. (3800° F.).

(2571) U. S. 1,520,794 (1924). F. W. Zons, *Refractory Alloy.* The alloy is produced by packing and heating a mixture of powdered metal alloys such as 2-20% W, remainder Ta.

(2572) U. S. 1,566,534 (1925). E. Haagn (W. C. Heraeus G.m.b.H.), *Production of Tungsten Alloy.* The alloy consists of a mixture of 80-90% W, 10-17% Pt and 1-3% Ir compressed into a small block and exposed to an electric arc in reducing gas.

(2573) U. S. 1,569,095 (1926). C. A. Laise (Electron Relay Co.), *Filaments of High Electron and Light Emission.* A filament is composed of alloys of powdered W, Th and V mixed with refractory light-emitting oxides.

(2574) Brit. 279,490 (1927). British Thomson-Houston Co. Ltd., *Hard Metal Alloys.* Hard alloys of Fe with W and/or Mo are heated until a solid solution is formed and then rapidly cooled and tempered.

(2575) U. S. 1,623,784 (1927). G. R. Fonda (General Electric Co.), *Filament.* A filament alloy of W, Th and Cu is sintered, swaged and drawn.

(2576) U. S. 1,653,630 (1927). E. Kiam and M. G. Collins, *Nickel-Tungsten Alloy.* An alloy suitable for use in contact with acid liquid or vapor is composed of 30-65% Ni, 15-40% W, 1-8% Mn, .5-5% Mg, and 15-30% Cr.

(2577) U. S. 1,663,560 (1928). G. W. Meister (Westinghouse Lamp Co.), *Filament.* Evaporation of a tungsten filament is reduced by adding, in addition to doping with ThO_2, powdered Mo to W in order to form an alloy.

(2578) U. S. 1,665,636 (1928). J. W. Marden (Westinghouse Lamp Co.), *Filament.* W is mixed with ThC_2, formed and heat treated.

(2579) U. S. 1,668,734 (1928). E. E. Schumacher (Western Electric Co.), *Cathode.* A W filament for a thermionic cathode is heated in vacuum with powdered U to form an alloy which has a certain thermionic activity.

(2580) U. S. 1,703,577 (1929). H. Falkenberg, *Tungsten Alloy.* A journal bearing alloy contains W powder.

(2581) U. S. 1,731,244 (1929). W. B. Gero (Westinghouse Lamp Co.), *Electron Emitting Body.* An electron-emitting body is produced by mixing pure W and Mo powder with 1% Th, pressing and slowly heating the compact in a high vacuum until the particles coalesce.

(2582) U. S. 1,731,255 (1929). J. W. Marden (Westinghouse Lamp Co.), *Alloy and Its Manufacture.* A W-Ta alloy is produced by mixing powdered W with Ta-oxide, pressing, sintering in vacuo to consolidate and reduce, and heat-treating at about 2000° C. (3630° F.) to diffuse.

(2583) U. S. 1,731,267 (1929). M. N. Rich (Westinghouse Lamp Co.), *Resistance Alloy.* An alloy resistant to corrosion at elevated temperatures is composed of 60-80% Cr and 20-40% W. The powder mixture is ball milled and pressed into bars or rods and sintered in H_2.

(2584) U. S. 1,732,326 (1929). H. S. Cooper (Kemet Laboratories Co.), *Thorium Alloy and Method of Producing Same.* Ductile and substantially oxide-free alloys are composed of Th with a refractory metal of the W group by mixing Th-hydride with the refractory metal, compacting, heating to dissociate the hydride and further heating to form an alloy.

(2585) Brit. 335,081 (1930). J. Gray and Metallgesellschaft A. G., *Manufacture of Alloys.* Sodium tungstate is mixed with a solution of Na_2SiO_3, HCl, and the precipitate of WO_3 + SiO_2 is dried and heated in H_2; then the mass is mixed with

Mg powder and heated to the reaction temperature, whereupon Mg reduces the SiO_2 to Si. The MgO is dissolved with hydrochloric acid, and the mass is brought into contact with Cu and heated in an electric furnace to produce a homogeneous alloy of W and Cu.

(2586) German 505,964 (1930). Kemet Laboratories Co., *Production of Thorium Alloys.* Th hydride is mixed with W and shaped under high pressure, then decomposed in H_2 at high temperatures.

(2587) Austrian 125,468 (1931). Allgemeine Glühlampenfabriken A. G., *Holder for Filaments.* The body consists of a W-Mo alloy whose W content is larger than the Mo content; *e.g.*, 52% W and 48% Mo.

(2588) French 716,635 (1931). K. Kenkyujo, K. Honda and T. Kase, *Hard Alloys.* The alloys contain W and/or Ta with Cr, Mo and/or V as principle constituents and small quantities of Ni and/or Fe.

(2589) Japan. 91,603 (1931). K. Kamishima, *Tungsten-Zirconium Alloy.* An alloy used for cutting tools consists of 10-90% W and 90-10% Zr; Fe, Co, Ni, Cr, Mo, Al, Mn, C serve as binding media, and 1-10% Be or Ta are added to maintain hardness.

(2590) U. S. 1,800,691 (1931). A. E. MacFarland (Sirian Wire & Contact Co.), *Alloy for Filaments.* The alloy consists of 90% Mo, 9% W, and 1% Cr.

(2591) U. S. 1,803,189 (1931). S. L. Hoyt (General Electric Co.), *Hard Refractory Alloy.* 95 parts W, 5 parts B_4C and 15 parts Co are pressed in graphite dies at 1350° C. (2460° F.).

(2592) U. S. 1,809,780 (1931). C. L. Gebauer (Ohio Instrument Manufacturing Co.), *Forming Articles From Powdered Alloys Containing Tungsten.* W, Mo, Ta are mixed with a powdered metal of a lower melting point, such as Cu, compacted and heated above the melting point of the second metal.

(2593) U. S. 1,811,487 (1931). E. C. Belding (National Tool & Metals Inc.), *Hard Alloy Suitable for Facing Cutting Tools.* The alloy has a composition of 55% Ta, 41% W and 4% Mo.

(2594) Brit. 370,566 (1932). W. Müller, *Hard Refractory Metal Alloy.* The alloy is produced by melting or sintering, and consists of 38-98% W, 0-57% Fe, 2-9.5% Be, and 0-3% C.

(2595) U. S. 1,881,315 (1932). K. Honda and T. Kase (Research Institute for Iron, Steel & Other Metals), *Hard Tungsten-Chromium-Molybdenum Alloys Suitable for Cutting Tools.* The hard metal is composed of 30-50% W, 20-50% Mo, 30-50% Cr and less than 2% C.

(2596) Brit. 387,699 (1933). K. Kamishima, *Sintered Zirconium-Tungsten Alloy.* A refractory alloy for cutting tools, dies, heating elements of electric furnaces, etc., comprises 20-90% Zr, balance W; up to 20% Fe, Al and/or Mn, and 0.5-10% Ta may be added.

(2597) Brit. 395,745 (1933). N. V. Molybdenum Co. and P. Schwarzkopf, *Compound Structural Material for Shaped Articles.* Metals of a first group consisting of W, Mo, or Ta are sintered and powdered and mixed with metals of a second group consisting of Ag, Al, Cu, or Pt, and if desired with metals of a third group consisting of Ti, V, Zr, Co, Ni, or Fe; the consolidation is carried out below the sintering temperature of the metals of the first group.

(2598) French 741,871 (1933). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Sintered Hard Alloys For Tools.* A composition of 30% W, 23% Co and 47% Fe in powdered form is mixed, compressed, sintered, quenched and reheated.

(2599) German 568,033 (1933). P. Schwarzkopf, *Thermionic Discharger.* The cathode is composed of a solid solution alloy of Mo with an alkali earth metal.

(2600) U. S. 1,916,410 (1933). P. H. Brace (Westinghouse Electric & Mfg. Co.), *Refractory Metal-Base Alloy.* An alloy between a refractory metal and a chemically reactive metal such as Ba or Ca which is volatile at low temperature is produced by employing powder metallurgical methods.

(2601) U. S. 1,926,775 (1933). K. Kamishima, *Sintered Zirconium-Tungsten Alloy. Cf.:* Brit. 387,699 (No. 2596).

(2602) Brit. 408,642 (1934). Johnson, Matthey & Co., Ltd., E. R. Box and A. R. Powell, *Hard Metals Containing Precious Metals Such as Osmium or Ruthenium.* The composites contain 40% of Os or Ru, and Fe, Co, Ni and up to 5% P, Si, B, Ti or Al.

(2603) Brit. 408,662 (1934). Johnson, Matthey & Co., Ltd., E. R. Box and A. R. Powell, *Hard Metals Containing Precious Metals of the Platinum Group.* The alloy contains at least 4 elements, (1) W or Mo; (2) Fe, Co or Ni; (3) Pt-metals; and (4) C, Si, B, Al; Ti or Sn may also be added.

(2604) Swedish 82,472 (1934). K. Kamishima, *Zirconium-Tungsten Alloy.* The alloy consists of 50-90% Zr, balance W, with 0.5-10% Be or Ta.

(2605) Brit. 447,567 (1936). General Electric Co. Ltd. and C. J. Smithells, *Heavy Sintered Tungsten Alloys.* Shields against penetration of radiation are made by mixing fine W and Cu or Ni powder and sintering to 1500° C. (2730° F.); a binder may be used.

(2606) German 625,046 (1936). E. J. Kohlmeyer and K. Grassmann, *Production of Alloys of Refractory Metal.* The refractory metal oxides are mixed with NiO, heated and reduced in H_2 atmosphere.

(2607) German 635,170 (1936). W. Müller, *Hard Alloy for Tools.* 95% W, Mo or Cr powders with 5% Be are mixed with 30-45% Fe, Ni or Co powders, compacted and sintered.

(2608) Brit. 472,281 (1937). General Electric Co. Ltd. and C. J. Smithells, *Tungsten-Copper-Nickel Alloys.* An alloy used for massive rotating members, fly wheels, crank shafts, etc. is composed of 90-95% W, 3-5% Ni, and 2-5% Cu; the powders are pressed and sintered above 1350° C. (2460° F.) to give a density above 15 g./cc. and strength better than that of Pb.

(2609) German 643,567 (1937). N. V. Molybdenum Co. and P. Schwarzkopf, *Binary Alloy.* W, Mo, Ta, are sintered and crushed, mixed with Cu, Al, Pb, Sn, Zn, and then heated until the latter type metals are melted.

(2610) U. S. 2,070,451; 2,082,719 (1937). E. R. Box and A. R. Powell (Johnson-Matthey & Co., Ltd.), *Precious Hard Metal Alloys.* Ir, Os and Ru (40-94.5%) are alloyed with 3-28% of a binder, *e.g.* Co or Ni, and up to 40% W and 0.5-5% B is added.

(2611) Brit. 497,747 (1938). General Electric Co. Ltd. and C. J. Smithells, *Improvements in Heavy Alloy.* An alloy of W-Cu-Ni with a density not less than 16 g./cc. is composed of 91% W, cemented by a Cu-Ni alloy of a 2.6-6.4 ratio.

(2612) U. S. 2,132,116 (1938). H. R. Kiepe (Baker and Co.), *Palladium Alloys Suitable for Jewelry, Switch Contacts, etc.* Alloys of Pd plus 0.5-15% Ru and 5-15% Cu produced from powders show improved hardness.

(2613) Brit. 500,114 (1939). Rheinmetall-Borsig A. G. and G. Boecker, *Refractory Metal Alloys.* Refractory metals such as Mo or Ta and binding materials such as Ni or Co are subjected to heat treatment until shrinkage is complete, whereupon the mass is pulverized, compressed into form, and sintered.

(2614) Brit. 506,299 (1939). General Electric Co. Ltd. and C. J. Smithells, *Bearings.* Bearings are manufactured by sintering a mixture of W powder with Ni, to produce an alloy consisting of large W grains cemented together by an alloy of W-Ni.

(2615) French 841,092 (1939). General Electric Co. Ltd., *Heavy Alloy.* The alloy contains 0.5% Cu or 3.5% Ni, balance W, and is formed from powders and sintered to produce an alloy of 16 g./cc. density.

(2616) German 675,871 (1939). Stahlwerke Röchling-Buderus A. G., *Sintered Body.* Bodies produced of W, Mo, Ta or Ti powder contain up to 15% of a Cu-Be alloy, containing 0.3-7% Be of the entire alloy; the mixture is pressed and sintered.

(2617) German 681,403 (1939). Deutsche Edelstahlwerke A. G., *Hard Metal Bodies.* Powdered W, Mo, Ta, are sintered, crushed and mixed with lower melting metals, then heated to the melting temperature of the lower melting metals.

(2618) U. S. 2,157,934; 2,157,935; 2,157,936 (1939). K. L. Emmert and F. R. Hensel (P. R. Mallory & Co.), *Refractory Alloys of Tungsten, Molybdenum and Rhenium.* Typical compositions obtained by using powders are (1) 80-99% W, 1-20% Mo, 0.01-10% Re; and (2) 40-80% W, 20-60% Mo, 0.01-25% Re.

(2619) U. S. 2,165,310 (1939). C. Spaeth, *Tungsten Alloy Filaments.* The filaments are manufactured by winding W wire on an Fe core. On heating the Fe vaporizes and deposits on the W; the resulting alloy contains both Fe and W.

(2620) U. S. 2,183,359 (1939). C. J. Smithells (General Electric Co. Ltd.), *Method of Manufacture of Heavy Metallic Material.* Metallic material is composed of large grains of W cemented together by a W-Ni-Cu alloy with a density of not less than 16 g./cc.

(2621) Brit. 517,442 (1940). General Electric Co. Ltd. and C. J. Smithells, *Alloy.* An alloy having a density of 10-15 g./cc. is composed of Mo, W, Ni, Cu, with the proportion by weight of Ni being greater than that of Cu, and the proportion by weight of Ni + Cu being not so great that the pressed bodies lose their shape during sintering.

(2622) Brit. 531,117 (1940). General Electric Co. Ltd. and G. H. S. Price, *Heavy Alloys.* Continuation and addition to Brit. 497,747 (No. 2611). A mixture of W, Mo, Ni and Cu is heated to 1400° C. (2550° F.) to obtain a high density.

(2623) U. S. 2,188,405 (1940). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co.), *Molybdenum Alloy.* The alloy consists of Mo with 0.01-1% Os.

(2624) U. S. 2,202,108 (1940). C. A. Laise, *Refractory Metal Alloy Composition.* The alloy consists of more than 90% W, less than 10% Al and 0.5% V.

(2625) Swiss 218,696 (1942). General Electric Co. Ltd., *Heavy Metal Alloy.* The alloy is produced from W, Mo, Ni, Cu, in which the percentage of Ni is higher than that of Cu, and both together are not more than 15%; the other constituents are mixed in such proportions that the density is between 10 to 15 g./cc.

(2626) German 742,965 (1943). Heraeus-Vacuumschmelze A. G., *Metallic Materials Resistant to Attack of Zinc.* Sintered parts of 90% Mo and 10% Fe powder can be used in hot-galvanizing baths without suffering any attack from molten metal. Complicated parts are assembled by hot pressing them with a thin layer of Fe powder.

(2627) Swiss 225,247 (1943). Licentia Patent-Verwaltungs-Gesellschaft m.b.H., *Cathode of Thorium.* The product consists of a porous tube of Mo or W whose pores are filled with Th; it has high emission, good mechanical properties, and high electrical resistance.

(2628) U. S. 2,360,606 (1944). R. F. Huddleston (P. R. Mallory & Co.), *Valve Guide.* The product is provided with a scraper ring of hard refractory metal with a composition of 55-65% Mo and 45-35% Ag.

(2629) U. S. 2,389,060 (1945). J. Kurtz (Callite Tungsten Corp.), *Alloy for Refractory Body of High Electronic Emission.* A refractory metal body having high electronic emission when heated consists of 99% W and Mo, 0.25% Ni, 0.25% Be and 0.50% Pt. The body has a foraminated structure and a coating of electron emitting oxides both on the external surface of the body and on the surface of the foramina within the body.

(2630) U. S. 2,391,455; 2,391,456 (1945). F. R. Hensel (P. R. Mallory & Co.), *Spark Plug.* W, Ni and Mo powders are used to form a center electrode for the spark plug.

(2631) U. S. 2,391,459 (1945). F. R. Hensel (P. R. Mallory & Co.), *Spark Plug.* A center electrode of loop form is made of powders from high W-base alloys.

(2632) U. S. 2,413,604; 2,413,605; 2,413,606 (1946). W. H. Colbert and A. R. Weinrich (Libbey-Owens-Ford Glass Co.), *Refractory Metal Alloy Filament for the Vacuum Evaporation of Metals.* The usual filaments of W, Ta, Mo can be used for evaporation of Ag, Cu, Au by adding small quantities of a mutually alloyable metal such as Fe, Ni or Co.

(2633) Canadian 442,725 (1947). Callite Tungsten Corp., J. Kurtz and H. G. Williams, *Alloys of High Density.* W, Mo, Re or Ta are alloyed with a 0.25-4% mixture of (1) 25% Mn, Fe, Co, Ni; (2) 25% of Be, Zr, Cr, V, Ti; and (3) 50% Pt, Pd, Au, Os.

(2634) Brit. Appl. 31139/48 (1948). Lumalampan A. B., *Sintered Alloy.* Mo wire is admixed with 30% ZrO_2 in order to increase the specific resistance on starting up.

(2635) Brit. 611,466 (1949). General Electric Co. Ltd. and I. Jenkins, *Powder Metallurgical Process.* Production of fine ducts in gas turbine blades entails embedding a wire of low melting point metal in a pressing of a high melting point powder; subsequent heat treatment will produce either diffusion or evaporation of the wire, depending upon the given combination of metals. For example, Sn wire is embedded in Mo in a die and compacted; after sintering, an oval-shaped duct is formed, with the Sn being impregnated in the Mo compact.

(2636) Brit. 617,057 (1949). Callite Tungsten Corp., J. Kurtz, and H. G. Williams, *High Density Alloy.* A W or Mo alloy of theoretical density is obtained without swaging by sintering with a binder of 1% by weight of an alloy of 25% Ni, 25% Be, 50% Pt.

(2637) Brit. 622,141 (1949). Mallory Metallurgical Products Ltd., *Hard Metal Composition.* Gramophone needle tips, pen points, cutting tools, pivot bearings or drawing dies are made from the following fused and disintegrated compositions which are ball-milled: (*1*) 50% Os or Ru, 33.4% WC, 16.6% Co; and (2) 20% Os, 15% Pt or 10% Rh, 30% WC, 30%-35% W, 5% Co.

(2638) Brit. 623,625 (1949). M. Littmann and Compound Electro Metals Ltd., *Bearings.* The bearings are made from porous WC compacts impregnated with Ag or Ag alloy.

(2639) Brit. 625,651 (1949). The General Electric Co. Ltd. and D. A. Boyland, *Mounts for Refractory Incandescent Elements.* A W rod is mounted in the end pieces of heavy alloy.

(2640) Brit. Appl. 1492/49 (1949). Skoda Works, *Process of Producing Objects from Tungsten-Cobalt Alloys.* A ball-milled mixture of W and Co powders is pressed, sintered at 1450° C. (2640° F.) and machined to size. The compacts are then subjected to grain refining by heating to 1500° C. (2730° F.) for 10 minutes followed by oil-quenching and tempering. Carburization is then effected by heating the compacts at 1450° C. (2640° F.) in city gas or hydrogen-hydrocarbon gas mixtures, to produce a carbide facing.

(2641) U. S. 2,466,992 (1949). J. Kurtz, *Tungsten-Nickel Alloy of High Density.* A W-Ni alloy having a density of more than 17 g./cc. consists of 84-94.5% W, 5-15% Ni and 0.05-1.0% Pt. Pt, or other added metals, such as Ag or Pd, are preferably added as solutions of water soluble compounds to the Ni and W powders by stirring, after which they are reduced to metal. Despite high density and hardness, the alloy has good machinability.

(2642) U. S. 2,467,675 (1949). J. Kurtz and H. G. Williams (Callite Tungsten Corp.), *Alloy of High Density.* The method involves combining a purified refractory metal powder, such as W or Mo, with a small amount of powdered metals which result in the alloying, bonding, and densifying of a rod or ingot without the necessity of swaging. Example: A 50:50 Pt-Ni mixture of very fine powder is prepared; 0.5% of this mixture is added to fine W powder, ball-milled, compacted and sintered at 1500-1800° C. (2730-3270° F.) in H_2; shrinkage is 15-25%, density without swaging is 19.35 g./cc.

(2643) U. S. 2,470,790 (1949). T. Price (Westinghouse Electric Corporation), *Manufacture of Alloys.* A mixture of powdered oxide of Cr and powdered carbide of Mo is used in a method of manufacturing coherent Cr alloys of Mo and W.

(2644) U. S. 2,490,571 (1949). R. J. Anicetti (Metal Hydrides, Inc.), *Pyrophoric Alloys.* Flints for cigarette lights are made from a composition of 35% Zr, 35% Pb and 30% Ti.

2. HARD METALS AND COMPOSITIONS

A. Hard Metal Compound Compositions

i. Single Refractory-Metal Carbide-Base

(2645) U. S. 1,023,299 (1912). H. R. Connell (General Electric Co.), *Method of Making Meter Jewels.* The method comprises heating W to high temperature in a C mold containing a small cavity thereby causing the W to take up C and assume a concave upper surface shape.

(2646) German 286,054 (1915). O. Ruff, *Zirconium Carbide and Titanium Carbide.* A manufacturing process for very fine powdered ZrC and TiC entails heating the metallic oxides mixed with C to a temperature below the melting point of the carbides.

(2647) German 286,184 (1915). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Method of Producing Parts of any Desired Size from Tungsten and Molybdenum Carbide.* A process for the manufacture of WC or Mo_2C pieces of any given size comprises adding powdered coal to W or Mo-oxide or anhydride.

(2648) German 289,066 (1915). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Production of Tools or Dies of Tungsten.* WC or Mo_2C is milled to a very fine powder, pressed and heated to a temperature near the melting point of the carbide.

(2649) German 292,583; 295,656 (1916). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Carbides.* WC or Mo_2C is sintered in Fe dies in reducing atmosphere.

(2650) German 295,726 (1916). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Production of Pieces from Tungsten Carbide.* Addition to German 289,066 (No. 2648). Mo or a Mo compound is added to the fine carbide powder prior to the second heating.

(2651) Swiss 91,932 (1919). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Carbides. Cf.:* German 289,066 (No. 2648).

(2652) Swiss 93,496 (1919). Voigtländer & Lohmann Metallfabrikations G.m.b.H., *Carbides. Cf.:* German 295,656 (No. 2650).

(2653) U. S. 1,343,976; 1,343,977 (1920). A. J. Liebmann and C. A. Laise, (Independent Lamp and Wire Co.), *Hard Metal Alloys.* A process of hardening refractory metals comprises subjecting them to a high heat in the presence of C and another metal, thereby producing vapors which cause cementing and alloying. Example of a composition is 91% W, 2¼% Th, 6% Fe, ¼% C.

(2654) Brit. 185,313 (1922). Aktiengesellschaft B. Felder-Clement, *Material of Great Hardness for Tools.* The process involves use of crude WC containing free C fused with MoO_3, Mo_2C or molybdic acid, to yield WC without free C.

(2655) Brit. 213,524 (1924). General Electric Co. Ltd., *Tungsten Carbide Alloy for Dies.* Powdered WC with 3-10% C content is mixed with 10% of an auxiliary metal.

(2656) German 419,388 (1925). Siemens & Halske A. G., *Hard Alloy.* Method of producing hard alloys containing Co, Cr, W and C involves reduction by C of mixtures of the respective metal oxides, whereby C is present in sufficient quantity to saturate the alloying requirements of the metals after their reduction. C may first be combined with one of the metals (*e.g.* W) after reduction, and the other metals may only be added thereafter.

(2657) German 420,689 (1925). Patent Treuhand Gesellschaft für Elektrische Glühlampen and K. Schröter, *Hard Metal Alloy for Tools.* Alloy consists of WC with 3-7% C and 10% auxiliary metal such as Fe, Ni, Co, and is produced by pressing and heating successively or simultaneously.

(2658) U. S. 1,549,615 (1925). K. Schröter (General Electric Co.), *Hard Metal Alloys.* Pulverized WC with 3-10% C is mixed with an auxiliary metal as Fe or Ni in finely divided state; the mixture is pressed and sintered at a temperature which lies 1000° C. (1800° F.) degrees below the melting point of the pure carbide.

(2659) Brit. 239,499 (1926). Gewerkschaft Wallram, *Heavy Metal Carbides.* A process for manufacturing refractory metals or carbides comprises a single high temperature melting of the raw materials (such as W, Mo, Ti, Cr, B) in an electric graphite tube furnace with current supply terminals. Following this, the product is cast in molds.

(2660) Brit. 251,929 (1926). General Electric Co. Ltd., *Tungsten Carbide Alloy for Dies and Tools.* Improvement of Brit. 213,524 (No. 2655). WC (6% C) is heated during carbonization in a C-containing gas, *e.g.* C_6H_6, so that the small particles adhere only loosely; mixture contains 10-20% of an auxiliary metal, such as Co, Fe, Ni.

(2661) German 434,527 (1926). Patent-Treuhand Gesellschaft für Elektrische Glühlampen and K. Schröter, *Sintered Hard Alloy.* Addition to German 420,689 (No. 2657). 10-20% of the auxiliary metal is added.

(2662) German 427,074 (1926). Siemens & Halske A. G., *Alloy for Tools.* An alloy of W, Cr, Co, and C is fused, and another alloy containing 1% Cr, 2% Co and up to 20% WC, is added to the melt.

(2663) Brit. 274,866 (1927). W. Schrobsdorff, *Hard Metal Alloy.* The alloy is composed of Ta as the solvent and predominant constituent, plus a carbide of W, Mo, U, or Cr.

(2664) Brit. 278,955 (1927). Fried. Krupp A. G., *Sintered Hard Metal Alloys.* The WC, forming the main constituent of the alloy, contains the entire C content of 5.2-6.2% in combined form; the powder is produced in oxidizing atmosphere in a gas furnace, or in a reducing atmosphere in a hydrogen furnace from W powder and lampblack. The WC powder is mixed with Fe, Co, or Ni powder, briquetted, and sintered to form the hard alloy.

(2665) French 620,177 (1927). Fried. Krupp A. G., *Production of Tools of Hard Metal.* The mixed powders of WC and Co or Ni are pressed and presintered, worked to the desired form and sintered again.

(2666) Swiss 126,013 (1927). Metallabor A. G., *Carbides for Tools.* WC is sintered with Fe, Co, Ni, Mn, Cr and Ta additions.

(2667) Austrian 111,835; 111,836 (1928). Fried. Krupp A. G., *Sintered Hard Metal Article. Cf.:* Brit. 279,376 (No. 2668).

(2668) Brit. 279,376 (1928). Fried. Krupp A. G., *Sintered Hard Metal Articles.* Finely powdered WC and Fe, Ni and Co are intimately mixed; the mixture is subjected to a further grinding process of at least 50 hours, so that each carbide particle is covered with thin Co coating and the resulting particle size averages 0.1 μ; the mixture is then pressed to form bodies and sintered at 1300-1600° C. (2370-2900° F.).

(2669) Brit. 288,521 (1928). British Thomson-Houston Co. Ltd. and S. L. Hoyt, *Carbide Alloy.* Mixtures of a powdered refractory metal of the Cr-group and a metal of the Fe-group such as Co are heated with C at 1300-1450° C. (2370-2640° F.) under pressure of 1000 psi.

(2670) Brit. 289,477 (1928). British Thomson-Houston Co. and E. G. Gilson, *Hard Alloys of Tungsten, Chromium.* W or Cr, and Co as binder, are mixed with C and sintered in dies with C electrodes at 1300-1450° C. (2370-2640° F.).

(2671) French 642,203; 642,204 (1928). Fried. Krupp A. G., *Alloys for Tools.* The alloy contains WC with 5-6% C, and Ni or Co as binder, and is sintered in H_2; the grain size of the powder is smaller than 0.1 μ.

(2672) French 654,210 (1928). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Alloy.* Powdered W is mixed with C, pressed and heated in the presence of CH_4 and then sintered.

(2673) French 655,216 (1928). F. W. Rauth, *Alloys for Tools.* Electrolytic Fe or Cr powder is used as binder for WC in the presence of about 5% Cu or Mn.

(2674) Hung. 97,051; 98,262 (1928). Allgemeine Elektrizitäts-Gesellschaft, and E. G. Colonie, *Hard Alloy.* WC is mixed with an Fe-group metal or Cu and hot-pressed at 70 kg./cm.^{2} (1000 psi) at 1300-1450° C. (2370-2640° F.). W, C and Co or Cu may be sintered together under high pressure at high temperatures.

(2675) Japan. 79,188 (1928). S. L. Hoyt, *Hard Alloy.* WC is mixed with a Fe-group metal and cold pressed and sintered or hot pressed.

(2676) Austrian 113,511 (1929). Fried. Krupp, A. G., *Tools of Sintered Hard Metal Alloys.* The mixture of WC and Co, Ni, or Fe is formed and pre-sintered, at 700-1100° C. (1290-2010° F.), then machined nearly to its finished form and sintered again at a higher temperature, followed possibly by a final grinding operation.

(2677) Brit. 303,751 (1929). British Thomson-Houston Co. Ltd. and F. C. Kelley, *Hard Material for Tools and Dies.* Details are given of a sintering procedure of a mixture of W, Co and C with or without binder.

(2678) French 655,208 (1929). F. W. Rauth, *Manufacturing of Alloys for Tools.* Sintered alloys of WC or Mo_2C with Fe binder are cooled very quickly to a temperature at which the C is still dissolved; the brittle material is heated again to a temperature at which the C is dissolved by one of the elements of the alloy.

(2679) Swed. 69,243 (1929). Fried. Krupp A. G., H. Voigtländer and O. Kaufels, *Production of an Alloy Containing Tungsten Carbide or Molybdenum Carbide.* WC or Mo_2C are produced by melting; the product is then powdered, pressed and sintered.

(2680) Swiss 129,647 (1929). Fried. Krupp A. G., *Sintered Hard Alloy. Cf.:* Brit. 278,955 (No. 2664).

(2681) Swiss 130,203 (1929). Fried. Krupp A. G., *Hard Metal Alloy.* An alloy of WC plus 5% Co with a pore size smaller than .01 mm. is made from raw material with a particle size smaller than .0001 mm.

(2682) U. S. 1,721,416 (1929). K. Schröter (General Electric Co.), *Composition of Hard Metal Carbides Suitable For Cutting Tools Or Wear-Resisting Articles.* A sintered hard and tough metal composition consists mainly of WC and Co binder.

(2683) U. S. 1,721,966 (1929). O. L. Mills, *Tungsten Alloy Production.* WC is mixed with 3-20% WO_3 and 15-20% metallic W, then fused in a carbon arc furnace.

(2684) U. S. 1,737,255 (1929). P. M. McKenna (Vanadium Alloy Steel Co.), *Carbides.* Finely powdered W plus 3-7% lampblack are heated in a graphite die to 1300° C. (2370° F.). The carbide is mixed with 4.4 parts Be and sintered for 7 hours at 1300° C. (2370° F.).

(2685) U. S. S. R. 14,471 (1929). Patent-Treuhandgesellschaft für Elektrische Glühlampen, *Hard Metal Alloy.* WC is mixed with an auxiliary metal, pressed and sintered.

(2686) Brit. 310,885 (1930). Fried. Krupp A. G., *Hard Alloys. Cf.:* German 587,117 (No. 2757).

(2687) Brit. 319,698 (1930). British Thomson-Houston Co. Ltd., and F. C. Kelley, *Tungsten and Like Metal Carbides.* The method of manufacture of WC comprises placing 94% W powder and 6% C powder in a porous C vessel, and heating the closed vessel in H_2 above 1000° C. (1830° F.).

(2688) Brit. 335,453 (1930). R. Walter, *Sintered Alloys Containing Tungsten Carbide.* The alloy is composed of 50-80% WC or carbonitride or both, together with Fe, Mn, Ni, Cr, W, Mo, U or their carbides.

(2689) French 38,878 (Addn.) (1930). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys.* Addition to French 654,210 (No. 2672). Alloys of WC and Co are cemented with Cu which is later removed.

(2690) French 685,640 (1930). R. Walter, *Carbides.* WC plus 5-30% W or Cr and containing Co is pressed and sintered.

(2691) French 689,027 (1930). Firth-Sterling Steel Co., *Hard Alloy for Cutting or Abrasive Purposes.* The particles of WC are coated with Co by electrolysis and heated until the Co is melted.

(2692) French 697,611 (1930). Firth Sterling Steel Co., *Tool Material.* Co, Fe, Cu or Ni powders are first coated and then mixed with WC, SiC, or ZrO_2. The mixture is heated under pressure.

(2693) French 698,333 (1930). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Carbides.* A powdered carbide of the 6th group of the periodic system, e.g., W, Mo, or Cr, is mixed with U and hot-pressed at 60 kg./cm.^{2} (850 psi) at 1500-1660° C. (2730 - 3020° F.).

(2694) Swiss 140,173 (1930). Fried. Krupp, A. G., *Hard Metal Alloy.* 80% W, plus 20% C, and Ni, Cr, Co, Fe or Si are melted, powdered and sintered.

(2695) U. S. 1,742,417 (1930). W. Schrobsdorff, *Production of Metal Alloy and of Articles made Thereof.* A cast object is composed of a metal alloy containing from 50-98% Ta and a carbide of a metal of the Cr-group.

(2696) U. S. 1,756,857 (1930). E. G. Gilson (General Electric Co.), *Hard Metal Composition, Such as Used for Machining Cutting Tools.* The manufacturing method comprises mixing powdered W, C and an element of the Fe-group and applying pressure to the powder mixture at the sintering temperature of the mixture.

(2697) U. S. 1,757,846 (1930). K. Schröter and H. Wolff (Fried. Krupp A. G.), *Manufacture of Hard Metal Tool Bodies.* Tool bodies are composed of powders such as carbides with a binding medium formed into the desired shape by mechanical working and then subjected to a high sintering temperature.

(2698) U. S. 1,775,014 (1930). R. L. Adams (General Electric Co.), *Hard Metal Body.* A dry mixture of WO_3 and C is slurried with an aqueous solution of Co acetate and the mixture heated and annealed in reducing atmosphere, after which it is pressed and sintered.

(2699) U. S. S. R. 22,267 (1930). V. D. Romanov and W. J. Riskin, *Hard Metal Alloy.* A powdered hard metal such as WC is blended with a salt solution to form an alloy, then reduced, pressed and sintered.

(2700) U. S. S. R. 22,895 (1930). V. D. Romanov and W. J. Riskin, *Hard Alloys.* Hard alloys of WC and a cementing metal are heated to effect sintering.

(2701) U. S. S. R. 23,620 (1930). L. P. Mol'kov and G. Y. Dillon, *Sintered Hard Metal Alloys.* The alloys consist of WC or Mo_2C plus Co or W-Co which are mixed with resin and pressed in a hot form.

(2702) Austral. 960/1931; 1325/1931 (1931). Fansteel Products Co., and C. W. Baike, *Hard Metal Alloy.* The alloy consists of Ta, C and Ni.

(2703) Austral. 1329/1931 (1931). Fansteel Products Co., and C. W. Balke, *Hard Metal Alloy. Cf.:* Brit. 376,266 (No. 2727).

(2704) Brit. 346,473 (1931). A. E. White, *Material for Cutting Tools.* WC is galvanized-coated with a low-melting metal, such as Co, then pressed and sintered.

(2705) Brit. 346,632 (1931). British Thomson-Houston Co. Ltd. and R. L. Adams, *Hard Metals Comprising Tungsten, Carbon and Cobalt.* A dry mixture of C and W-oxides is added to an organic solution of Co-acetate; the mixture is evaporated and heated.

(2706) Brit. 355,041 (1931). British Thomson-Houston Co. Ltd. and F. C. Kelley, *Carbide Alloy.* WC is blended with 9% Mn, formed, and sintered at 1300° C. (2370° F.).

(2707) Brit. 355,782 (1931). Vereinigte Stahlwerke A. G., *Hard Alloy Composition.* Co and Ni are used together with 10-40% W and 2-5% C; part of the W may be replaced by Mo. The mixture is sintered.

(2708) Brit. 359,427 (1931). British Thomson-Houston Co. Ltd., and L. L. Wyman, *Carbides.* WC plus Co (25%) has 3% ThO_2 added to avoid grain growth, and is pressed and sintered.

(2709) Brit. 360,709 (1931). British Thomson-Houston Co. Ltd., and S. L. Hoyt, *Tool Alloys.* The alloys consisting of 97-80% WC and 3-20% Co are hot pressed at 1375° C. (2505° F.) into the desired shape.

(2710) French 38,897 (1931). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Alloy.* Addition to French 654,210 (No. 2672) in

which WO_3 and C are bathed in diluted Co-acetate. The solution is evaporated and the residue heated in reducing atmosphere, then pressed and sintered at 1500° C. (2730° F.).

(2711) Hung. 105,367 (1931). Allgemeine Elektrizitäts-Gesellschaft, *Binder for Tantalum Carbide.* The binder consists of 3-20% of a mixture of 47-63% Fe and 53-37% Mo, or 45-66% Ni and 55-34% W.

(2712) Swedish 71,064 (1931). E. A. Grönwall, *Tungsten Carbide Alloy.* To the WC alloy is added not less than 15% of a metal containing 10-15% Mn, besides Fe, Co, Ni.

(2713) U. S. 1,792,943 (1931). J. T. Terry, *Tungsten Carbide Alloys.* CaO is added to W to control the C content in WC and W_2C.

(2714) U. S. 1,794,229 (1931). S. L. Hoyt (General Electric Co.), *Tungsten Carbide for Making Hard Tough Metal Products.* Powdered WC is mixed with Co pressed, and sintered, followed by additional sintering under high pressure.

(2715) U. S. 1,794,300 (1931). F. C. Kelley (General Electric Co.), *Hard Alloy For Tools.* W plus 25% Co and 3-10% C is mixed with 3% organic binder, pressed, heated to volatilize the binder, and then sintered.

(2716) U. S. 1,815,613 (1931). G. J. Comstock (Firth Sterling Steel Co.), *Hard Metal Alloys.* WC or another hard, high-melting substance, 3-20% Mn, and a Mn-steel containing 0.25-1.25% C, all in powder form, are mixed with an organic binder and water, pressed, and heated to the melting point of the steel. The amount of the high-melting carbide is greater than that of the Mn-steel.

(2717) U. S. 1,822,426 (1931). E. B. Welch (Firth Sterling Steel Co.), *Composition of Hard Tool Alloy.* Co powder particles are coated alternately with Cu and Cr, then mixed with WC.

(2718) U. S. 1,822,720 (1931). L. L. Wyman (General Electric Co.), *Tungsten Carbide Composition Suitable for Dies for Drawing Wire.* WC is mixed with 25% Co and 3% ThO_2, pressed and sintered.

(2719) U. S. 1,826,454; 1,826,456 (1931). G. J. Comstock (Firth Sterling Steel Co.), *Composition of Matter.* The material is composed of a sintered aggregate of finely divided SiC or ZrO_2 (from 50-95%) in a matrix of Ni.

(2720) U. S. 1,829,950 (1931). H. Voigtländer, and O. Kaufels (Fried. Krupp A. G.), *Process for the Manufacture of Difficultly-Fusible Heavy Metals.* The process comprises mixing metals difficult to melt with C in powder form, in a quantity required to form pure carbide, melting the mixture down in an electric furnace, and casting the molten mass outside the furnace at the moment of correct degree of carburization.

(2721) U. S. 1,831,567 (1931). F. C. Kelley (General Electric Co.), *Hard Metal Alloy containing Manganese.* Mn is used as cementing material for WC to be used in the manufacture of articles such as cutting tools.

(2722) U. S. 1,833,099 (1931). E. B. Welch (Firth Sterling Co.), *Method of Making a Composition of Matter.* A cutting or abrading material is made by coating powdered WC with Co by electrodeposition and sintering above the melting point of Co, but below that of WC.

(2723) Austrian 131,092 (1932). W. L. A. Hasselbach, *Carbide Alloys.* Alloys for instruments, tools, molds, etc. contain one or more metallic carbides of W, Mo, U, Ti and one or more of auxiliary metals of Fe, Ni, Co, Cr, used as electrolytic powders.

(2724) Brit. 364,718 (1932). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Carbides.* Mixtures of a carbide of the 6th group, (preferably W) and Co or another Fe-group metal, are pressed and sintered. The product is again powdered, pressed and sintered.

(2725) Brit. 373,708 (1932). Fansteel Products Co., *Hard Metal Alloy for Cutting Tool.* A cutting tool alloy comprises 10% Ni and remainder 94.25% Ta with 5.75% C, in which all the C is chemically combined with the respective amount of Ta to TaC, but with an excess of Ta being present.

(2726) Brit. 373,711 (1932). W. L. A. Hasselbach, *Carbide Alloys. Cf:* Austrian 131,092 (No. 2723).

(2727) Brit. 376,266 (1932). Fansteel Products Co. and C. W. Balke, *Hard Metal Alloys.* A sintered alloy contains WC or TaC and from 5 to 9% of a metal of the Fe-group (especially Ni). The alloy should not contain free W or Ta.

(2728). Brit. 380,941 (1932). E. A. Grönwall, *Hard Alloys.* An alloy for tools consists of WC, 3-20% W powder and at least 12% of an alloy containing 50-85% W, balance Fe, Ni, Co, Cr, Ti, V, or Mo.

(2729) Brit. 383,942 (1932). Fried. Krupp A.-G., *Sintered Iron Tungsten Alloys.* The alloy preferably contains 62% W, 4.3% C, and 32.7% Fe.

(2730) French 729,381 (1932). Comp. Française Pour L'Exploitation des Procédés Thomson-Houston, *Procedure and Apparatus for the Fusion and the Deposit of Pulverulent Materials.* Co-cemented WC on a base of Fe backing is sintered in H_2.

(2731) French 732,875 (1932). E. A. Grönwall, *Hard Metals of Tungsten Carbide.* An impure W is used to lower the sintering temperature or amount of auxiliary metal to be added.

(2732) French 739,986 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys.* A sintered alloy is composed of CbC plus some addition of W or Ta, and Fe, Co, Ni as binder.

(2733) German 555,786 (1932). Allgemeine Elektrizitäts-Gesellschaft, *Hard Metal Alloy.* WO_3 and C are immersed in diluted Co-acetate. The solution is evaporated and the residue heated in reducing atmosphere, then pressed and sintered at 1500^0 C. (2730^0 F.).

(2734) Japan. 95,459 (1932). I. Iitaka, *Tungsten Monocarbide.* The production of WC comprises treating W_2C with Cl_2 and separating the reaction product from the C-residue; the chloride vaporizes.

(2735) Japan. 95,561 (1932). K. K. Sumitomo Densen Seizojo and H. Kyukichi, *Hard Alloy.* A mixture of powdered WC or carbide of Mo or Cr (92%), Co or Fe and Ni (6%), B_4C or diamond (2%), and glycerol, is molded and sintered in H_2 or N_2.

(2736) U. S. 1,839,518 (1932). G. W. Woods and H. B. Woods (Hughes Tool Co.), *Method of Forming Tungsten Carbides.* The manufacturing of WC entails melting powdered W and C in a graphite crucible and immersing the molten carbide in a liquid bath or a mold containing fused salts.

(2737) U. S. 1,843,768 (1932). S. L. Hoyt (General Electric Co.), *Hard Metal Composition Containing Tungsten, Carbon and Cobalt.* Compositions suitable for cutting tools, wire drawing dies, etc. are formed by mixing the powdered materials, and simultaneously heating and pressing.

(2738) U. S. 1,848,899 (1932). P. M. McKenna (Vanadium Alloy Steel Co.), *Composition of Matter.* A material used for cutting tools, dies, etc., is composed of a sintered mixture of 17-69% W or Mo, and 83-31% of a carbide of V, Cb, or Ta.

(2739) U. S. 1,855,994 (1932). E. Schnebel (Fried. Krupp A. G.), *Production of Hard Metal Alloy Without Addition of Low-Melting Point Metal.* Shapes of homogeneous alloys of great hardness are produced by melting a mixture of a metal of high melting point with a metalloid of the C-group, subjecting the molten mass to a texture-refining heat treatment, pulverizing the alloy, pressing into shape and sintering below the recrystallization temperature of the alloy.

(2740) U. S. 1,858,244; 1,858,300 (1932). C. A. Laise (Callite Products Co.), *Carbide Alloy.* An alloy of high hardness consists of 60-90% WC or Mo_2C plus 2-25% Al or Ta-oxide and also a Fe-group metal.

(2741) U. S. 1,864,567 (1932). R. Walter, *Tool Alloys Comprising Tungsten.* Tool alloys consist principally of a pressed and sintered carbonaceous W-compound powder together with a homogeneously mixed nitrogenized metal of the Fe or Cr-group.

(2742) U. S. 1,876,175 (1932). W. F. Stoody and T. Relling (Stoody Co.), *Metal Carbides.* Metal carbides, *e.g.* WC, are produced by sintering a mixture of finely divided metal, *e.g.* W, and a paste of C with petroleum oil.

(2743) U. S. 1,892,653 (1932). P. M. McKenna (Vanadium Alloys Steel Co.), *Hard Alloy.* A hard alloy is manufactured by sintering powdered WC and Ta by subjecting the mixture to high-frequency currents at temperatures below the melting point.

(2744) Brit. 386,043 (1933). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Obtaining Coherent Hard Metals From Powders.* Sintered bodies contain 2 or more constituents such as Ni, Co, Cu and WC.

(2745) Brit. 386,359 (1933). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Alloys For Electric Furnaces, Tools, etc.* Hot-pressed carbides of W are produced by electrically heating and pressing.

(2746) Brit. 388,090 (1933). British Thomson-Houston Co., Ltd. and F. C. Kelley, *Sintered Hard Metal Compositions For Cutting Tool Bits.* TaC plus Ni, Co, or Fe are produced by pressing and sintering.

(2747) Brit. 390,236 (1933). British Thomson-Houston Co., Ltd. and F. C. Kelley, *Sintered Hard Metal Compositions For Cutting Tool Bits.* The alloys consist of TaC plus a cementing material of Cc and Al (13% of 90/10 Co/Al).

(2748) Brit. 391,933 (1933). British Thomson-Houston Co. Ltd. and F. C. Kelley, *Sintered Metal Compositions.* The alloys consist of CbC and one or more metals of the Fe-group; WCor Mo_2C may be added.

(2749) Brit. 395,064 (1933). British Thomson-Houston Co., Ltd. and F. C. Kelley, *Sintered Alloys From Tantalum Carbide.* A sintered alloy comprises powdered TaC and a metal binder consisting substantially of Co and W, and is pressed and sintered at 1300-1600° C. (2370-2910° F.).

(2750) Brit. 395,719; 395,721 (1933). W. W. Triggs, *Shaped Bodies of Hard Metals.* Alloys are composed of (*1*) 85-95% WC and 15-5% Co; and (2) 80% WC and 20% W.

(2751) French 745,076 (1933). Fagersta Bruks A. B., *Tools of Sintered Metal Carbides.* Metal carbide powders, *e.g.* WC, are mixed with Fe, Co or Ni, pressed and heated prior to sintering to produce a chemical reaction leading to better coherence.

(2752) French 747,436 (1933). J. H. L. De Bats, *Manufacture of Synthetic Alloys.* An alloy consisting of 70-99% WC and 30-1% Co is manufactured by general procedures of powder metallurgy, including preparation of powder, mixing, cold or hot compression and sintering.

(2753) French 752,049 (1933). Fansteel Products Co., *Sintered Hard Metal Alloys.* The alloys contain a carbide such as TaC (80%), a refractory metal such as W or Mo (9%), and a binder such as Ni (11%).

(2754) French 754,762 (1933). Comp Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloy.* The alloy consists of ZrC mixed with up to 30% of Co, Fe, Ni, or Cr.

(2755) French 758,891 (1933). E. Schjöth, *Method of Manufacturing Alloys of Hard Metal Carbides.* Colloidal suspensions of the carbide and binder constituents are made separately, emulsified in absence of air, and the sediment is separated, dried, pressed and sintered.

(2756) German 571,292 (1933). Siemens & Halske A. G. and B. Fetkenheuer, *Titanium Carbide.* Compressed pieces of C with a Ti alloy (Fe-Ti) are heated to 1800° C. (3270° F.) and the product is purified.

(2757) German 587,117 (1933). Fried. Krupp A. G., *Production of Bodies of Metal Carbides.* Alloys of W or Mo with C and a lower melting metal are fused, then powdered, pressed and sintered at 2000-2400° C. (3630-4350° F.).

(2758) Japan. 101,748 (1933). Mitsubishi Zosen K. K., I. Iitaka and A. Kozo, *Tungsten Carbide Alloy.* A hard alloy suitable for making tools is formed by hot-pressing a mixture of 95% WC and 5% V at 1700° C. (3090° F.).

(2759) Swedish 77,227 (1933). E. A. Grönwall, *Hard Sintered Tungsten-Cobalt Alloys.* The alloys consist of W-carbides (WC and W_2C are both used) and W, Co with or without free C, and with or without Cr and Ni.

(2760) Swiss 159,719 (1933). Vereinigte Edelstahl A. G., *Hard Metals.* 39% of at least one carbide of a metal of the 4th group of the periodic table (*e.g.* Ti or Zr) plus 5-22% of an auxiliary metal is annealed, mechanically worked, and sintered.

(2761) Swiss 160,217 (1933). P. M. McKenna, *Hard Metal for Tools.* The alloy consists of 70-30% WC and balance Cr; the powder is mixed and pressed at 280 kg./cm.^{2} (2 tsi) and sintered in an induction furnace at 2000° C. (3630° F.).

(2762) Swiss 161,100 (1933). Fried. Krupp, A. G., *Sintered Hard Alloy.* The alloy consists of 75% TiC and 25% Ni, or 95% TiC and 5% Co.

(2763) Swiss 162,515 (1933). Fansteel Products Co., *Hard and Tenacious Alloy.* The alloy consists of 97-85% TaC with 5-6.2% C, and 3-15% Fe or Ni.

(2764) U. S. 1,893,078 (1933). J. W. Genuit (Stoody Co.), *Sintered Hard Metal Composition Suitable For Drilling Bits etc.* The alloy is composed of 90-97% WC, 0.5-5% Mo, and 2-9.5% Ta.

(2765) U. S. 1,895,364 (1933). S. P. Billings (General Electric Co.), *Resintering of Salvaged Cemented Carbides.* Material containing mainly WC and Co-scrap is heated in large pieces in a mold above 1000° C. (1830° F.) under pressure.

(2766) U. S. 1,895,950 (1933). H. Voigtländer and O. Kaufels (Fried. Krupp A. G.), *Shaped Articles Comprising Carbides of Tungsten or Molybdenum.* The process of producing shaped bodies containing a predominant percentage of carbides from W or Mo consists of preparing a fused alloy of 80% carbide and 20% of a metal with lower melting point, cooling, and giving the mass the desired shape by applying pressure to the body at a temperature of 2200-2400° C. (3990-4350° F.).

(2767) U. S. 1,905,505 (1933). A. P. Roux (General Cable Corp.), *Tungsten Carbide Compositions.* Alloys suitable for wire-drawing dies are prepared by sintering the WC powder mixture in C molds, and pressing during cooling.

(2768) U. S. 1,910,884 (1933). G. J. Comstock (Firth Sterling Steel Co.), *Method of Making Hard Metal Compositions.* Separate layers of a porous compacted body of hard abrasive particles, (such as WC), and a compacted body of bonding metal particles, are heated together, thus causing the bonding metal to flow into the interstices of the abrasive particles.

(2769) U. S. 1,913,100 (1933). C. W. Balke (Ramet Corp. of America), *Hard Alloy of Tantalum Carbide and Nickel.* A hard product suitable for tools is formed by grinding TaC in Ni-lined mills (thereby adding comminuted Ni from the grinder to the TaC powder), mixing, pressing, and sintering.

(2770) U. S. 1,918,064 (1933). G. F. Taylor (General Electric Co.), *Method of Making Strong Thin Cemented Carbide Disks.* Cutting disks are produced by hot-pressing fine-grained cemented WC.

(2771) U. S. 1,924,384 (1933). W. F. Stoody (Stoody Co.), *Tough Tungsten Carbide Alloy.* A cast alloy is made from mixed powders of 2½-18% Ni, 2½-18% Cu, remainder W, with sufficient C to form the carbide.

(2772) U. S. 1,928,453 (1933). F. C. Kelley (General Electric Co.), *Sintered Metal Containing Tantalum Carbide.* A hard, tough material suitable for cutting tools etc. comprises TaC and 3-20% of Fe, Ni and Co together with up to 1% Al.

(2773) U. S. 1,936,435 (1933). F. C. Kelley (General Electric Co.), *Tantalum Carbide Cutting Tools.* A hard tough sintered composition consists of TaC together with a binder, making up about 3-25% of the composition and consisting substantially of W plus Cu.

(2774) U. S. 1,937,185 (1933). C. W. Balke (Ramet Corp. of America), *Tantalum Carbide Alloys for Cutting Tools.* TaC powder is degasified in vacuum at a temperature above 600° C. (1100° F.); then mixed with 3-15% of Ni powder and pressed and heated to 1300-1400° C. (2370-2550° F.) in vacuum.

(2775) U. S. 1,940,308 (1933). F. C. Kelley (General Electric Co.), *Method of Making Carbides.* The preparation of a carbide of a metal of the W-group comprises mixing 94% of the metal with 6% C and placing it in a tube having inner walls of C and heating in H_2 above 1000° C. (1830° F.).

(2776) U. S. S. R. 32,158 (1933). I. S. Gaev and B. I. Belyaev, *Hard Cutting Alloys.* A powder mixture of WC with C and a cementing metal is pressed and sintered.

(2777) Austrian 136,255 (1934). Allgemeine Elektrizitäts Gesellschaft, *Hard Metal Alloys for Tools.* More than 20% of an Fe-group metal, such as Co, plus WC is sintered at 1300-1450° C. (2370-2640° F.) and pressed at 70 kg./cm.^{2} (1000 psi).

(2778) Austrian 136,284 (1934). Allgemeine Elektrizitäts Gesellschaft. *Hard Alloys for Tools.* 3-10% C, 5-25% Co, remainder W powder, with 2% resin as binder, is resistance-sintered in a protective atmosphere.

(2779) Austrian 138,630 (1934). R. Walter, *Sintered Refractory Materials For Tools.* A mixture of 80% WC (or nitrogenized WC), 5-19% Cr, W or Mo, remainder Fe, Mn, Ni or Co singly or mixed, is pressed and sintered.

(2780) Brit. 406,633 (1934). Tool Metal Manufacturing Co. Ltd., *Hard Alloy.* The alloy contains TiC as principal constituent and 1-30% of a lower melting metal, such as Co or Ni.

(2781) Brit. 412,098 (1934). Wolfram & Molybdän A. G., *Sintered Hard Alloys.* A powdered mixture comprises up to 30% of one or more alloys of Fe, Ni, Co with Ti, Zr, Hf, Ta, Cb, V or Mo, balance W_2C. The mixture is sintered at 1400-1700° C. (2550-3090° F.).

(2782) Brit. 415,697 (1934). Deutsche Edelstahlwerke A. G. and Siemens-Schuckertwerke A. G., *Production of Hard Alloy Bodies.* A hard alloy for tools contains hard metal carbides and a binding metal mixed with a lubricating medium, which later is expelled by heating.

(2783) Brit. 416,353 (1934). Fansteel Products Co., *Tantalum Carbide Alloys.* Alloys of TaC (80%) and Ni (11%), W or Mo (9%) suitable for use as tools are sintered at 1400° C. (2550° F.) in vacuum or inert atmosphere; TaC is produced at 2000° C. (3630° F.) by passing H_2 over a mixture of Ta and C.

(2784) Brit. 420,544 (1934). G. Y. Dillon, *Hard Metal Alloys. Cf:* French 761,932 (No. 2789).

(2785) Canadian 343,023 (1934). Fansteel Products Co. and Ramet Corp. of America and C. W. Balke, *Sintered Hard Alloys and Method of Making Same.* Ta, Mo, Cb or W powder is united with B or C and Fe metal and then sintered.

(2786) Canadian 343,731 (1934). Canadian General Electric Co., Ltd., *Cemented Tantalum Carbide.* TaC is mixed with 3-20% of a binding metal, consisting of Fe with 10% Al.

(2787) Canadian 344,546; 344,547 (1934). Canadian General Electric Co., Ltd., *Cemented Columbium Carbide.* The CbC is mixed with a binder consisting of Fe and a metal of the 6th group (*e.g.*, Cr, Mo or W).

(2788) Canadian 344,762 (1934). Ramet Corp. of America and C. W. Balke, *Tungsten Carbide Alloys.* WC and an auxiliary metal (Ni, Fe, Co) are powdered, pressed and sintered at 1400-1500° C. (2550-2730° F) for 1½ hours in vacuum, N_2, H_2 or dissociated NH_3.

(2789) French 761,932 (1934). G. Y. Dillon, *Hard Metal Alloys.* The alloys contain WC or Mo_2 and an easily fusible metal in the form of a colloidal solution.

(2790) French 765,893 (1934). Union Aciers Fins, S.A., *Hard Metal Carbides.* The alloys are produced by exposing carbide-forming metals to carbonyls in gaseous hydrocarbon atmosphere. The resulting metal carbide is mixed with a binder and sintered.

(2791) Swiss 168,785 (1934). Fried. Krupp A. G., *Sintered Hard Metal Alloy.* The alloy is composed of ZrC and up to 30% Ni, Fe, Cr, or Mn.

(2792) Swiss 169,409 (1934). Fansteel Products Co., *Tantalum Carbide Alloys. Cf.:* Brit. 416,353 (No. 2783).

(2793) Swiss 174,138 (1934). Wolfram & Molybdän A. G., *Sintered Hard Alloy.* An alloy suitable for tools consists of 93.5% of WC containing 0.1-0.5% free C and Co or Ni mixed with their oxides, and is sintered above 1400° C. (2550° F.).

(2794) U. S. 1,947,206 (1934). F. C. Kelley (General Electric Co.), *Cemented Columbium Carbide.* A sintered composition which is suitable for cutting hard rubber or "Mycalex" contains 3-25% of metallic binder, such as a mixture of Fe and Mo, balance CbC.

(2795) U. S. 1,973,422 (1934). E. B. Welch (Firth Sterling Steel Co.), *Hard Metal Composition Suitable For Cutting Tools and Dies.* The composition consists of 15-60% TiC, 25-82% W and 3-15% Al.

(2796) U. S. S. R. 37,854 (1934). V. D. Romanov, V. S. Rakovski, V. I. Tretyakov, R. A. Trubnikov, V. P. Lvovskaya, N. E. Levina, and E. M. Belostotzkaya, *Method of Cementing Hard Refractory Carbides.* Powdered WC or other hard compounds are introduced into a chamber in which a cementing material is being reduced and vaporized.

(2797) Brit. 425,882 (1935). Acidia and G. Boecker, *Sintered Hard Metals.* A spray of finely divided dry refractory metal carbide and a spray of an adhesive agent are so directed that they meet on their way to the mold which is filled with a compact moist mass, which subsequently is sintered.

(2798) Brit. 438,414 (1935). Wolfram & Molybdän A. G., *Cemented Hard Alloy.* Free C or an oxide of the carbide-forming metal or of the binder is intentionally added to obtain uniform porosity.

(2799) Brit. 439,529 (1935). Norton Co., *Formed Article.* B_4C, free of impurities, is produced by hot-pressing.

(2800) French 780,081 (1935). Acidia and G. Boecker, *Sintered Hard Metals. Cf:* Brit. 425,882 (No. 2797).

(2801) French 784,229 (1935). J. Mayor, *Sintered Cemented Carbides.* The material consists of 85% WC, 12% Co, 3% Ni or Mo, and is hot-pressed under vacuum in a furnace muffle.

(2802) French 786,055 (1935). Fagersta Bruks A. B., *Cemented Hard Compounds.* Cementing metals (Fe, Ni, Co) are added to carbides in form of oxides or carbonates which are decomposed by a gas to the metal and a volatile reaction product.

(2803) French 789,969 (1935). Wolfram & Molybdän A. G., *Sintered Hard Alloy. Cf:* Swiss 174,138 (No. 2793).

(2804) French 793,712 (1935). Siemens & Halske A. G., *Carbides.* Carbides of Ta, Ti, Mo, V, or U are diffused into steel or hard alloy below the melting temperature. Bonding metal such as Ni or Co can be used with the carbides.

(2805) German 608,772 (1935). R. Walter, *Sintered Refractory Alloy.* The alloy is produced by mixing, pressing and sintering of 50-80% WC, 5-30% Cr, W or Mo, balance Fe, Mn, Ni or Co.

(2806) German 618,125 (1935). Allgemeine Elektrizitäts Gesellschaft, *Sintered Cemented Tungsten Carbides.* The manufacture of hard metal alloys such as WC entails sintering them under pressure by electric heating currents, which are introduced only when a condenser charged with high frequency is discharged through the metal powders.

(2807) Swedish 84,903 (1935). Fagersta Bruks A. B., E. G. Larsson, G. L. T. Sterky, and K. M. Tigerschiöld, *Alloys of Cemented Hard Compounds.* In a modification of the common process of making hard metal alloys which comprises admixing metals as cementing binders, their reducible oxides are used instead and reduced during sintering.

(2808) Swiss 181,007 (1935). Acidia and G. Boecker, *Sintered Hard Metals. Cf:* Brit. 425,882 (No. 2797).

(2809) U. S. 1,991,233 (1935). G. F. Taylor (General Electric Co.), *Thin Cemented Carbide Disks.* The method comprises hot-pressing of WC into disks which have reinforcing Mo wires imbedded therein.

(2810) U. S. 1,992,372 (1935). J. Holzberger (Gebr. Böhler & Co. A. G.), *Sintered Titanium Carbide Alloys for Tools.* The alloys contain 35-45% Ti (as carbide), 20-30% Ni, 5-10% Cr, 10-20% W, and 6-10% C.

(2811) U. S. 1,993,598 (1935). J. H. L. De Bats, *Method of Mcking Refractory Alloys.* A mixture of WC and Co powders is first heated to 1800° C. (3270° F.), then hot-pressed at high pressure.

(2812) U. S. 1,998,609 (1935). G. J. Comstock (Firth Sterling Steel Co.), *Hard Cemented Carbide Materials.* A material suitable for dies, etc. is produced from WC ground in a container having a Cr, Ni or Co surface.

(2813) U. S. 2,011,369 (1935). P. M. McKenna (Vanadium Alloys Steel Co.), *Composition of Matter.* A hard alloy consists of 77% TaC, 16% W, balance Ni and Mn.

(2814) U. S. 2,019,331 (1935). M. R. Andrews (General Electric Co.), *Electric Incandescent Lamp.* A separately heated body of C is placed adjacent to, but out of direct contact with, a filament of a carbide of Ta, Hf, Zr or Nb.

(2815) Austrian 144,644 (1936). Gebr. Böhler & Co., A. G., *Hard Alloys From Titanium Carbide.* Specially prepared TiC is used as the basic hard material.

(2816) Austrian 145,675 (1936). Gebr. Böhler & Co., A. G., *Sintered Hard Metal Alloy.* The alloy comprises 88-95% TiC containing 11-14% C to give Ti_2C, with an auxiliary metal consisting of Be-alloy; the material is sintered and forged.

(2817) Austrian 145,807 (1936). Gebr. Böhler & Co., A. G., *Hard Metal Alloys.* The alloy comprises TiC and Cr, Mo, W, and 5-20% of a low-melting metal binder consisting of 60-20% Cu and 40-80% Fe, Co, Ni, Mn. The Cu may be replaced by Ag.

(2818) Austrian 146,169 (1936). Fansteel Products Co., *Hard Alloys for Tools.* The alloy comprises 3-15% of a Fe-group metal and 85-97% Ta carbide or boride.

(2819) Austrian 146,381 (1936). A. Kratky, *Sintered Refractory Compounds.* A powdered mixture of 90% WC, 2% Mo, and 8% Ni is molded under pressure and then strongly compressed and heated in a special apparatus, described in Austrian 137,185 (No. 2051).

(2820) Brit. 447,822 (1936). Edgar Allen & Co., Ltd., and G. Fodor, *Method of Making Cemented Carbide Tool Tips.* W_2C plus Co, Ni or Fe binder is mixed, ground in ball mills in the presence of an inert liquid, *e.g.* C_6H_6, moistened with water, pressed and sintered.

(2821) Brit. 448,423 (1936). P. R. Mallory & Co. and W. W. Briggs, *Hard Metal Alloy.* The alloy contains 30-65% Fe, 2-30% W, 3.5-6.5% C and 2-5% Ni (optional), also Cr and Mo.

(2822) Brit. 449,752; 449,753; 449,847 (1936). C. A. Laise, *Sintering of Metal Powders.* W, Ta, or Ti is mixed with binder metal and heated with C, or C and B, at 1250° C. (2280° F.), then crushed and mixed with oxides of Fe, Ni or Co and heated at 1500° C. (2730° F.) in H_2, pressed into forms, and sintered in a reducing atmosphere at 1400° C. (2550° F.).

(2823) Brit. 451,095 (1936). British Thomson-Houston Co., Ltd., *Recovering of Cemented Hard Carbide Compositions.* Carbide compositions are recovered from articles such as cutting tools by heat treating and crushing, pressing and resintering.

(2824) French 798,021 (1936). A. Kratky, *Method of Producing Hard Metal Bodies.* A metal carbide powder is mixed with an auxiliary metal powder and pressed to produce small bars which are heated up to 1500° C. (2730° F.); the bars are then cooled and powdered; the powder is sintered in usual manner.

(2825) French 803,263 (1936). Eisler Electric Corp., *Refractory Alloys from Carbides.* Two typical compositions are (1) 78.5% W, .5% Fe, 1% Th plus Cr, 6.5% C plus 13.5% Co; and (2) 84% W, .5% Fe, 1.2% Cr plus Th, 7.8% C plus B plus Co and 6.5% Ni. Ag, or Cu may also be used as binders.

(2826) French 803,823 (1936). Comp. Française Pour L'Exploitation des Procédés Thomson-Houston, *Sintered Hard Alloys.* Powdered WC and Co are mixed and heated to 1600° C. (2910° F.) in a C crucible.

(2827) German 629,794 (1936). R. Walter, *Sintered Refractory Materials for Tools. Cf:* Austrian 138,630 (No. 2779).

(2828) Swiss 183,504 (1936). A. Kratky, *Production of Hard Carbide Bodies.* 930 g. W is mixed with 70 g. lamp black and moistened with syrup, formed and preheated, then electrically heated at 1800° C. (3270° F.) and pulverized. The carbide is mixed with 10% Mo, pressed, and sintered in steps at 2000° C. (3630° F.) which occurs simultaneously with pressing at high pressure.

(2829) U. S. 2,027,763 (1936). G. Boecker (Acidia), *Sintered Hard Metals. Cf:* Br. 425,882 (No. 2797).

(2830) U. S. 2,039,822 (1936). P. M. McKenna (Vanadium Alloy Steel Co.), *Tantalum Carbide Compositions for Cutting Tools.* Particles of W metal of a size of 1-100 milli-microns and in a proposition of 10-28% are used with 90-72% TaC.

(2831) U. S. 2,042,684 (1936). E. Schjöth, *Homogeneous Mixtures of Hard Materials For Tools and Dies.* The hard material WC and matrix metal (Ni) in separately formed colloidal suspensions of opposite electrical charges in liquid media are mixed to cause floculation and precipitation; the precipitate is separated, dried and sintered.

(2832) U. S. 2,044,853 (1936). C. A. Laise (Eisler Electric Corp.), *Method of Making Cutting Tools.* Cutting tools are manufactured by reducing with H_2 mixed oxides of a refractory metal, *e.g.*, Ta, and binder metal, *e.g.*, Cr, carburizing the product, lightly compacting and molding the resulting mixture at a high temperature, and then subjecting the molded product to a high pressure.

(2833) U. S. 2,053,151 (1936). F. C. Kelley (General Electric Co.), *Sintered Hard Metal.* TaC is combined with 3-20% binder, which consists of 34-55% of a metal of the 6th group, *e. g.*, Ca, Mo, or W, and 55-56% of a metal of the Fe group.

(2834) U. S. 2,057,786 (1936). O. L. Mills (Mills Alloys Inc.), *Making Tungsten Carbide Products.* The production comprises pouring molten WC into a mold, pressing without addition of heat until it is cool enough to be self-supporting, and then ejecting.

(2835) Brit. 461,872 (1937). Siemens & Halske A. G., *Sintered Hard Alloys.* Compositions claimed consist of W-, Mo-, Ti- or Ta-carbide (91-94%), Co (5-7%), W (0.3-1%), Cr (0.5-2%), and free C (0.05-.2%).

(2836) Brit. 471,571 (1937). H. A. Wilson Co., *Metal Mixture.* The alloy consists of WC plus 3-8% C and of an up to 20% Pt-group metal; the WC may be replaced by Mo_2C.

(2837) Brit. 471,862 (1937). Vereinigte Edelstahl A. G. and F. W. LeTall, *Method of Making Material for Sintered Alloy for Tools.* Refractory and auxiliary metal powders are carburized, cleaned, freed from impurities, and compacted and sintered; TiC is a major component.

(2838) Brit. 473,510 (1937). I. G. Farbenindustrie A. G., *Manufacture of Titanium and the Like Hard Carbides.* Graphite is removed from the carbides by heating to sintering temperature above 900° C. (1650° F.) together with Fe and/or Mn in an atmosphere of H_2.

(2839) Canadian 367,158; 368,916 (1937). Ramet Corp. of America and C. W. Balke, *Sintered Tantalum Carbide Alloy.* An alloy of great hardness and toughness for cutting tools consists of 3-15% Ni and the remainder Ta (95%) and C (5%) combined as TaC. To an alloy containing 11% Ni, 9% W is advantageously added.

(2840) French 47,522 Addn. (1937). Comp. Française Pour L'Exploitation des Procédés Thomson-Houston, *Hard Metal Carbides.* Addition to Fr. 726,718 (No. 3389). A layer of a mixture of WC and Co is produced, on which other layers of carbides of metals of the 4th or 5th group of the periodical system are built up with admixtures of Fe, so that the working surface has the smallest quantity of carbides.

(2841) French 807,700 (1937). The H. A. Wilson Co., *Hard Carbides.* The alloys are composed of a mixture of 80% minimum of WC and 1-20% of a metal of the Pt-group, *e.g.* Ir or Os, and an auxiliary metal, and are sintered under pressure.

(2842) French 813,162 (1937). G. Fodor and H. Garih, *Method of Making Cemented Carbides.* WC cemented with Ni, Co or Fe is ground in ball mills in C_6H_6 and wet pressed to briquettes prior to sintering.

(2843) French 817,022 (1937). Fédam S. A., *Hard Alloy.* The alloys consist of mixtures of WC, bronze and a metal of the Fe-group.

(2844) French 819,837 (1937). P. Brun, *Hard Alloys of Metal Carbides.* The alloys consist of metal carbides plus metals of the Fe-group. The latter are incorporated in the form of a salt which can be reduced to a metal during sintering.

(2845) German 649,622 (1937). Stahlwerke Röchling-Buderus A. G., *Nickel-Chromium-Carbide Alloy.* The alloy consists of 10-25% TaC or TiC, 10-35% Ni, and 5% Fe or 10% Al or 3% Zr, balance Cr.

(2846) Swiss 87,170 (1937). Fédam S. A., *Molded Article from Hard and Difficultly Fusible Alloys.* A mixture containing 2% Sn bronze, 5% Ni and 93% WC is placed in a graphite mold, pressed and heated.

(2847) U. S. 2,067,166 (1937). C. W. Balke (Ramet Corp. of America), *Tantalum Carbide Alloy for Tools etc.* A sintered TaC alloy contains 3-15% of a metal of the Fe-group like Ni.

(2848) U. S. 2,093,656 (1937). G. Fodor and H. Garih, *Carbides Suitable for Tipping Turning Tools.* WC and Fe, Co or Ni are milled in a liquid, such as C_6H_6, dried, pressed and sintered.

(2849) U. S. 2,097,140 (1937). C. R. E. Wohrman and P. H. Estes (H. A. Wilson Co.), *Sintered Hard Metal.* The alloy consists of a mixture of WC with 3-8% C plus up to 20% of a metal of the Os-Ru group.

(2850) Austrian 154,705 (1938). Siemens & Halske A. G., *Sintered Hard Alloy.* The alloy contains 91-94% WC, MoC, or TaC and 5-7% Co, 0.3-1% W, 0.5-1.5% Cr, and 0.05-0.2% C.

(2851) Belgian 427,884 (1938). N. V. Philips' Gloeilampenfabrieken, *Sintered Carbide.* A mixture of WC and Co is pressed at 500 kg./cm.^{2} (3½ tsi) and sintered in C-containing atmosphere.

(2852) Brit. 477,572 (1938). Fédam S. A., *Molded Article of Hard Alloys Difficult to Fuse.* A mixture containing 2% Sn bronze, 5% Ni, and 93% WC is placed in a graphite mold, pressed and heated.

(2853) Brit. 494,705 (1938). G. J. Comstock, *Cemented Carbides. Cf.:* U. S. 2,108,797 (No. 2864).

(2854) Brit. 497,144 (1938). N. V. Philips' Gloeilampenfabrieken and J. Romp, *Hard Metal Alloys.* WC and Co, C, Al_2O_3 and ZrO_2 are sintered into a hard alloy.

(2855) French 831,310 (1938). S. A. Le Carbone-Lorraine, *Tungsten Carbide Alloy.* The alloy consists of 80-96% WC, with more than 5.8% C, and a Cu-Co alloy.

(2856) French 831,990 (1938). A. Kratky, *Hard Alloy.* A powdered mixture of 94% WC, 1% V and 2% Co is pressed and sintered at 1400° C. (2550° F.); after cooling the body is powdered and mixed with 3% of a mixture of W and Co and sintered at 1600° C. (2910° F.).

(2857) French 833,555 (1938). S. A. Le Carbone-Lorraine, *Hard Alloys.* A hard alloy of mixed powders of W, Co, and C is sintered in an atmosphere containing a fuel.

(2858) French 833,556 (1938). S. A. Le Carbone-Lorraine, *Production of Sintered Hard Alloys.* WO_3 is mixed with Co_3O_4 and ground, then reduced with city gas at 900° C. (1650° F.) and carburized by adding C in H_2 at 1150-1300° C. (2100-2370° F.). The resulting powder is pressed and sintered.

(2859) German 670,725 (1938). Allgemeine Elektrizitäts Gesellschaft, *Hard Tantalum Alloy.* The alloy consists of 2.7-18% of Fe, Ni, or Co and 0.3-2% Al, remainder TaC.

(2860) German 670,769 (1938). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys.* The alloy consists of 50-96% of carbides, nitrides, borides or silicides of W, Mo, Ti or Ta and 4-50% of an auxiliary metal composed of W and Fe. The sintered body is slowly cooled to 1300° C. (2370° F.), then quenched and annealed at 900° C. (1650° F.).

(2861) Swedish 93,084 (1938). P. Marth, *Production of Hard Metal Alloys. Cf.:* Austrian 158,522 (No. 2890).

(2862) Swiss 196,018 (1938). P. Marth, *Sintered Hard Alloy.* Powdered W_2C is melted in the presence of H_2, mixed with Co, and sintered.

(2863) U. S. 2,106,161; 2,106,162 (1938). C. W. Balke (Ramet Corp. of America), *Manufacture of Hard Alloys For Tools.* Mixtures of TaC, Ni and W powders are sintered *in vacuo* to control shrinkage.

(2864) U. S. 2,108,797 (1938). G. J. Comstock, *Hard Cemented Carbide Composites Suitable for Razor Blades.* Ni and Ag are used as cementing agents for WC; pressing and sintering are controlled to give maximum hardness.

(2865) U. S. 2,113,171 (1938). H. S. Cooper (Cooper Products Inc.), *Hard Sintered Tungsten Carbide.* The production consists of pressing powdered substance containing 5.35-5.65% C and balance W into the desired shape and and sintering at 2300° C. (4170° F.).

(2866) U. S. 2,119,487; 2,119,488 (1938). H. N. Padowicz (Sirian Wire & Contact Co.), *Hard Metal Alloy for Cutting Tool.* WC or TaC is mixed with an aqueous solution of an acid salt of Co, Ni, or Fe (such as Co-acetate), dried, and heated in a reducing atmosphere.

(2867) U. S. 2,119,489 (1938). W. J. Beer (Sirian Wire & Contact Co.), *Refractory Metal Alloys.* A similar process as in U. S. 2,119,487 (No. 2866) can be used for mixtures of refractory metals and free C; the material is suitable for cutting tools.

(2868) U. S. 2,120,562 (1938). C. A. Laise (Eisler Corp.), *Hard Metal Products For Cutting Tools.* Powdered W, Ta, Ti, Cr, Re, or Th is mixed with Fe, Mn, Ni, Co, Ag or Cu; the mixture is sintered and carburized, powdered, mixed with binder, extruded in desired form, and resintered.

(2869) U. S. 2,121,448 (1938). G. Ritzau (Siemens & Halske A. G.), *Hard Materials For Tools.* 93% WC, 5.5% Co, 0.4% W 0.5% Cr and less than 0.1% C are sintered.

(2870) U. S. 2,124,538 (1938). J. A. Boyer (Carborundum Co.), *Boron Carbide Metal Composition.* A metallic composition suitable for making laps, etc., containing B_4C powder plus Fe, Co, Ni or Cu powder, is fabricated by mixing, pressing and heating.

(2871) U. S. 2,131,994 (1938). F. R. Hensel (P. R. Mallory & Co., Inc.), *Refractory Metal Compositions Suitable for Valve Seats, Bearings, Tools.* The alloys consist of WC, and intermetallic compounds of W, Si, Ni, Co, etc.

(2872) U. S. 2,133,495 (1938). F. H. Willey, *Method of Making a Hard and Compact Metal for Use in Formation of Tools, Dies, etc.* WC or another carbide of a metal of the 6th group of the periodic table is pressed and sintered.

(2873) Brit. 499,097 (1939). N. V. Philips' Gloeilampenfabrieken and J. Romp, *Hard Metal Alloy Articles.* A powdered mixture of WC and Co is compressed, sintered in C-containing atmosphere and then heated in a reducing atmosphere having a C-absorbing capacity.

(2874) Brit. 499,927 (1939). British Thomson-Houston Co., Ltd., *Hard Alloys.* WC is cemented with less than 1% of Cr_3C_2.

(2875) Brit. 500,114 (1939). C. A. Bolton Co. and G. Boecker, *Hard Metal Alloy.* A mixture of a metal carbide with W or Mo, and with Ni or Co as binder, is heat treated until the shrinkage is complete; then the material is pulverized, pressed and sintered. For example, 75% WC, 10% Mo, 8% V, 2% Ni, and 5% Si is heated rapidly to 2000° C. (3630° F.) at which shrinkage starts; this temperature is maintained for 2 hours.

(2876) Brit. 501,488 (1939). N. V. Philips' Gloeilampenfabrieken, *Hard Metal Alloy Production.* A method of producing hard metal alloys from powdered mixtures of elementary W, Co and C comprises sintering the mixture in a graphite mold at high pressure and at a temperature at which Co is not expelled, for such time that in the compacted mass only chemically combined and no free C is present.

(2877) Brit. 503,995 (1939). British Thomson-Houston Co., Ltd., *Hard Alloys.* A hard alloy for cutting tools consists of a sintered composition of WC with 5.9% C, and an alloy of Co with 10% Cu as binder.

(2878) Brit. 504,803 (1939). Metal Carbides Corp., *Manufacture of Articles from Metal Carbides.* Powdered metal carbides and a metallic binder are first heated to a predetermined temperature in a mold, whereupon the heating is discontinued and then pressure is applied to form the article.

(2879) Brit. 516,227 (1939). British Thomson-Houston Co., Ltd., *Hard Alloys.* A fine-grained mixture of refractory metals with Fe compounds is reduced in a carburizing atmosphere at 900° C. (1650° F.) in such a manner as to liberate powdered C, which is dispersed between the grains and prevents their enlargement; then the mixture is carburized by addition of C and sintered.

(2880) Brit. 516,275 (1939). Mallory Metallurgical Products Co., *Metallic Compositions.* The alloys consist of a refractory ingredient and a lower melting metal, *e.g.* ZrC and Cu, Ag, or Au.

(2881) French 837,577 (1939). N. V. Philips' Gloeilampenfabrieken, *Hard Metal Alloy Production. Cf:* Brit. 501,488 (No. 2876).

(2882) French 841,829 (1939). N. V. Philips' Gloeilampenfabrieken, *Objects of Hard Alloys.* W powder is mixed with 5% Ni and 6% C and the mixture is embedded in a mixture of 30% sugar coal with 70% powdered Al; the composition is pressed and annealed at 1450° C. (2640° F.) in H_2.

(2883) French 849,651; 849,652 (1939). F. Eisner, *Hard Alloys.* The alloys consist, for example, of 98% WC and 2% Mn and are heated at 1700° C. (3100° F.) in H_2.

(2884) Swedish 95,322 (1939). N. V. Philips' Gloeilampenfabrieken, *Hard Metal Products.* Starting with a powdered mixture of WC and Co, an impregnating material is employed whose C content is so adjusted that during sintering in non-oxidizing atmosphere, neither carburization nor decarburization takes place.

(2885) Swedish 95,909 (1939). Fagersta Bruks A. B. and E. A. A. Grönwall, *Production of Hard Metal Alloys.* Powdered WC is filled into a mold and poured over with molten Fe or steel.

(2886) Swiss 207,105 (1939). E. Looser-Warncke, *Sintering Pressed Hard Articles from Metal Powders.* A method for the production of sintered hard metals from a mixture of a carbide and binding metal consists of bringing the mixture to the melting temperature of the binder in vacuum for a short time and then cooling very quickly.

(2887) U. S. 2,147,329 (1939). F. H. Willey, *Wear-Resistant Metal Alloy.* The alloy consists of 76-87% WC, 20-9% Ni, 2.8% Mo, 1% Cr, and up to 10% Ti, and is submitted to heat and pressure to render it free from voids.

(2888) U. S. 2,160,670 (1939). M. Oswald (General Electric Co.), *Hard Alloys.* The production of the alloys entails mixing an oxide of a refractory metal with an oxide of lower melting point and reducing the mixture in a carburizing medium, then adding C and heating the mixture to 1300° C. (2370° F.) in H_2.

(2889) U. S. 2,176,802 (1939). J. Romp (N. V. Philips' Gloeilampenfabrieken), *Method of Making Hard Metal Alloys. Cf.* Brit. 499,097 (No. 2873).

(2890) Austrian 158,522 (1940). P. Marth, *Production of Sintered Hard Alloys.* WC is melted by an electric arc heating in the presence of atomic H, powdered, then mixed with auxiliary metals and sintered; the material can be used for drill bits.

(2891) Austrian 159,292 (1940). Fansteel Products Co., *Production of Hard and Tough Alloys.* A mixture of TaC, Ni, and W, containing up to 25% free metal, is heated *in vacuo* at 1100° C. (2010° F.) so that shrinkage starts; then heating is continued slowly to 1380° C. (2510° F.) to attain complete shrinkage, and to distribute the free metal equally in the TaC; the compositions have higher density than usual.

(2892) French 855,862 (1940). S. A. Le Carbone-Lorraine, *Hard Metal Alloy.* WC with 6% C is mixed with 6-20% pure Ag or a solid solution of another metal in Ag; the sintered alloy is corrosion resistant.

(2893) German 690,816 (1940). G. Boecker and P. Marth, *Sintered Hard Alloy.* The auxiliary metal (Fe, Ni, or Co) is introduced into the powdered carbide mass by way of its carbonyl in three different ways.

(2894) Italian 380,535 (1940). Fried. Krupp A. G., *Hard Metal Alloy.* The auxiliary metal consists of a mixture of 70-80% Co and 30-20% WC or Mo_2C and is heated and crushed.

(2895) Swiss 208,028 (1940). F. Eisner, *Production of Hard Metal Bodies Without Binder Metal.* A mixture of 98% WC and 2% Mn is pressed and sintered at 1700° C. (3090° F.) in rarefied H_2, whereby Mn agitates the surface of the grains of WC for better sintering before it is volatilized.

(2896) Swiss 210,374 (1940). W. Rüsch, *Production of Hard Metal.* Production comprises heating a mixture of a metalloid, fit for the development of a hard

material, and a compound of a metal of the group VIa of the periodic system, *e.g.* Cr, Mo, or W, which is reduced during the heating.

(2897) U. S. 2,189,387 (1940). W. A. Wissler (Haynes Stellite Co.), *Hard Composition.* Hard compositions are produced by electrically heating, then cooling, a carbide of a metal difficult to fuse, and a binding material such as pitch.

(2898) Austrian 160,589 (1941). Rheinmetall-Borsig A. G., *Manufacture of Tough and Hard Metal Products.* The production comprises an incomplete carburization of W powder with C at 1700-2000° C. (3090-3630° F.) for 3 hr., then a second, complete carburization with C at 1400-1900° C. (2550-3450° F.) for ½-6 hr.; forming of the body after addition of the metalloid powder, to the pulverized mixture and finish heating at 1600-1900° C. (2910-3450° F.) for 1 hr.

(2899) Brit. 538,721 (1941). British Thomson-Houston Co., Ltd., *Hard Alloys.* An anticorrosive alloy is obtained by bonding a refractory metal carbide with an alloy of Ag or Au and a metal of the Pt-group.

(2900) Brit. 539,129 (1941). H. L. Lehmann and A. Sondheimer, *Hard Metal Carbide Alloys.* A composition suitable for tool tips consists of WC plus Co and Ti, Fe, Cu, Mn, or Si.

(2901) French 866,892 (1941). L. Renault, *Hard Metal Alloy.* In the powdered mixture of a carbide with a binder metal, the Co is replaced by mixed crystals of Co with 10% Fe.

(2902) French 866,950 (1941). L. Renault, *Production of Pieces of Hard Metal.* The shaping by cutting is carried out after cold pressing of a mixture of WC and Co powder, but without presintering, to produce pieces without cracks, which then are submitted to a high temperature sintering.

(2903) German 713,795 (1941). Allgemeine Elektrizitäts Gesellschaft, *Sintered Hard Alloys.* WC and Co powder mixtures are heated up to 1600° C. (2910° F.).

(2904) Swiss 218,139 (1941). Fried. Krupp A. G., *Hard Metal Formed Body.* The material consists of a sintered matrix of refractory metals with Co binder in which are embedded hard metal pieces of great hardness whose sintering temperature is higher than that of the matrix.

(2905) U. S. 2,246,166 (1941). K. Schröter and W. Dawihl (General Electric Co.), *Sintered Hard Metal Alloys For Implements and Tools.* The manufacturing procedure comprises mixing Fe with a compound of W or Mo containing 1-5% C, heating the mixture to 1300° C. (2370° F.), crushing the product and employing it as a binder for pulverized carbide particles. Subsequent pressing and sintering of the mixture forms a cemented carbide.

(2906) Belgian 446,482 (1942). S. A. Le Carbone-Lorraine, *Tungsten and Molybdenum Carbides and Their Fritted Alloys.* Pulverulent W or Mo carbides are carburized to liberate N and a powdered metal or alloy is added. The mixture is fritted to produce highly abrasive carbides for crushers.

(2907) Brit. 550,133 (1942). Westinghouse Electric International Co., *Metal Carbides.* W_2C ultimately containing as little free C as possible is manufactured by mixing powdered W (92.75%) with powdered C (7.25%) and heating for 3 hours in H_2 at 1425-1450° C. (2600-2640° F.) in a refractory metal container.

(2908) German 730,893 (1942). J. Schreiner, *Sintered Metallic Bodies.* Hard metal bodies are made by sintering a powdered mixture of W and C by heating in an electric arc or in a gas flame applied to the outside of the mold and under a pressure of 3-60 kg./cm.^{2} (45-850 psi).

(2909) U. S. 2,286,672 (1942). W. W. De Lamatter (The American Steel & Wire Co.), *Hard Metal Article and Method of Making It.* Articles are produced from substantially pure WC.

(2910) U. S. 2,307,939 (1943). J. M. Merle, *Metal Product.* Powdered hard metals, such as metal carbides, are added to a stream of molten metal; the method is applicable to the manufacture of cutting tools.

(2911) Swiss 233,227 (1944). Radiamant A. G., *Hard Metal for Tools.* A mixture of 64% TiC, 18% W, 9% Mo, 6.1% Ni, 2.7% Co, and 0.3% SiC is pressed at 800 kg./cm.^{2} (6 tsi) and heated at 1600° C. (2910° F.) in a carburizing atmosphere; improvement is obtained by sintering under the influence of ultrasonic energy.

(2912) U. S. 2,363,575 (1944). W. DeLamatter and P. H. Hume (American Steel & Wire Co. of N. J.), *Hard Metallic Bodies of Great and Uniform Density*. WC is mixed with a lubricant in the presence of a wetting agent and is pressed and sintered.

(2913) Brit. 572,801 (1945). E. A. Seeley and Murex Ltd., *Shaped Articles of Sintered Metals*. WC powder, as the predominating ingredient, is molded with 3% thermosetting resin of the phenolic or urea-formaldehyde type resin at an elevated temperature and under pressure, then heated to drive off the resin and to sinter the powder.

(2914) Swiss 234,823 (1945). Radiamant A. G., *Manufacture of Hard Metals*. Carbide powders of Ti or Mo are mixed with 0.1-0.3% Ni or Co, pressed at 800 kg./cm.^{2} (6 tsi) and sintered at 1850° C. (3360° F.) in H_2, to avoid porosity of the body; the binder metal forms a homogeneous solid solution.

(2915) Brit. 579,052 (1946). Production Tool Alloy, Ltd. and D. H. Shute, *Hard Metal Products of Controlled Hardness*. Differential diffusion of binder imparts to cemented carbide tools regions of a greater or lesser hardness and brittleness. It is obtained by sintering and pressing of a mildly oxidized WC and 5% Co mixture on a thin layer of Co at 1450° C. (2640° F.) for 3 hrs. in an atmosphere of H_2 or cracked NH_3.

(2916) Brit. Appl. 430/48 (1948). British Thomson-Houston Co. Ltd., *Cemented Carbide Material*. A WC plate suitable for hard-facing purposes or as bearing material, is made by crushing the usual Co-bonded carbide to -40 plus 275 mesh and bonding with 15-50% of Cu, brass, bronze or Ag solder. Such double-bonded carbide has a coefficient of thermal expansion intermediate between that of carbon steel and single-bonded carbide.

(2917) Brit. Appl. 6066/48 (1948). Régie Nationale Des Usines Rénault, *Production of Metallic Carbides*. The production involves working and mulling 1250 g. W and 81.66 g. petroleum black (that has been calcined in H_2) in petroleum spirits to produce a thick cream. After the spirits are driven off, the powder is pressed, and sintered in graphite crucibles in H_2 atmosphere to 1400° C. (2550° F.) for 1 hr.

(2918) Brit. Appl. 31804/48 (1948). Skoda Works, *Production of Non-porous Sintered Hard Metals*. The shrinkage during final sintering is reduced by presintering to a temperature just above the melting point of the WC-Co eutectic, crushing, pressing and sintering. Toughness is improved by very slow cooling of the presintered material.

(2919) Brit. Appl. 32712/48 (1948). Skoda Works, *Producing Sintered Hard Metals*. Grain growth in cemented carbides is inhibited by admixing ThO_2, SiO_2 or Al_2O_3. Oxides of rare earth metals may be added as spectroscopic identification agents.

(2920) Canadian 456,146 (1948). Canadian Electric Co., Ltd. and E. W. Engle, *Making Thin Walled Sintered Articles*. Thin structures are made from a paste of WC, Co, and oil. The paste in a graphite crucible is presintered at 1000° C. (1830° F.); the article is removed from the crucible and sintered at 1500° C. (2730° F.).

(2921) Brit. 610,246 (1949). Mallory Metallurgical Products Co. Ltd., *Refractory Metal Compositions*. The use of both Co and Ag for bonding refractory carbides gives products of theoretical density.

(2922) Brit. 626,653 (1949). Régie Nationale Des Usines Rénault, *Manufacture of Sintered Hard Alloys*. WC powder is ground in a steel mill with steel balls, then treated with a solution of $CoCl_2$ under agitation and heating to evaporate water. The hot powder is exposed to H_2 for reducing the chloride coatings, and then processed by conventional means into sintered hard alloys.

(2923) Brit. Appl. 1491/49 (1949). Skoda Works, *Producing Hard Metals with High Heat Conductivity*. The addition of 0.5-3% Co to WC or TiC is claimed to increase the heat conductivity without detrimental effect upon hardness or mechanical strength.

ii. Multiple Carbide-Base

(2924) German 307,764; (1918). G. Fuchs and A. Kopietz, *Hard Alloy*. The alloy consists of 40-55% W, 30-40% Fe, 4-6% Ti, 2-4% C, and 2% Ce.

(2925) German 310,041 (1918). G. Fuchs and A. Kopietz, *Hard Alloy*. Improvement of German 307,764 (No. 2924). The alloy composition is 57% W, 33% Fe, 5% Ti, 3% C, and 2% Ce.

(2926) German 320,996 (1920). Gesellschaft für Wolframindustrie, *Hard Metal Alloy for Drawing Dies*. Improvement of German 310,041 (No. 2925). A small amount of chromium is added.

(2927) Brit. 157,747; 157,749; 157,750; 157,769; 157,770; 157,771; 157,772; 157,773; 157,774 (1922). Lohmann Metall Gesellschaft m.b.H., *Tungsten and Molybdenum Carbides for Tools, Dies, Bearings*. W, Mo, Ta, Ti, B, or Cr-carbides without binder are mixed and molded in C molds, then pressed and heated for sintering.

(2928) German 401,600 (1922). Gesellschaft für Wolframindustrie, *Alloys*. The alloys consist of 10 to 15 parts Ti, 75-84 parts W, and 2-3 parts rare earth such as Th, Zr, Ce, plus 3-5 parts C.

(2929) Austrian 94,522 (1923). Lohmann Metall Gesellschaft m.b.H., *Tungsten and Molybdenum Carbides for Tools, Dies, Bearings*. *Cf:* Brit. 157,747 (No. 2927).

(2930) Brit. 246,487 (1927). H. Lohmann, *Solid Bodies of Suitable Shapes from Carbides*. Solid bodies from carbides of metals with high fusing points are formed by mixing an acid of the metal or a highly reduced pulverulent oxide with Th, U, Ta, Mo, or their oxides.

(2931) Brit. 248,336 (1927). H. Lohmann, *Tungsten-Base Carbide*. WC bodies are obtained by fusing W with 5-10% ThC_2 plus 3-5% Mo in the presence of C.

(2932) Swiss 127,586 (1927). A. Kropf, *Alloys of High Melting Point*. The alloys contain 1.5% C, 50-90% W, and 0.5-50% Mo, Ta, Co, Cr, Ni, Fe, V, or Si.

(2933) Brit. 310,876 (1929). Fried. Krupp A. G., *Hard Alloy*. Shaped bodies are produced from WC or Mo_2C mixed with a lower melting metal by giving the alloy the desired shape by pressure while the body is at a softening temperature lying 10% below the melting temperature.

(2934) Brit. 316,702 (1929). R. Walter, *Hard Alloys For Tools*. The alloy consists of 2% $CrC_2 \cdot CrN$, 5% $2WC \cdot W_3N_2$, 8% Co, 5% W and 80% WC.

(2935) French 656,678 (1929). R. Walter, *Hard Alloy for Tools*. *Cf:* Brit. 316,702 (No. 2934).

(2936) Swiss 141,611 (1929). Fried. Krupp A. G., *Hard Metals*. Metals difficult to melt, such as W, and elements, such as C, are mixed with Ti, fused and then powdered, pressed and sintered.

(2937) Canadian 300,951 (1930). Canadian Westinghouse Co., *Tungsten-Tantalum Alloy*. W and Ta-oxide are mixed, carburized, reduced, powdered, pressed and sintered.

(2938) German 514,728 (1930). H. Voigtländer and O. Kaufels, *Alloys of Tungsten and Molybdenum Carbides*. The alloys are produced by hot-pressing (at 90% of the melting temperature) WC and Mo_2C and Fe, Co, Ni cementing agents.

(2939) U. S. S. R. 18,476 (1930). G. A. Meerson, *Hard Alloys From Tungsten and Molybdenum Carbides*. Powdered WC and Mo_2C are pressed and sintered in the presence of cementing agents, such as of Co and W.

(2940) Brit. 348,641 (1931). Olga, Prinzessin zu Lippe and W. Müller, *Hard Alloy*. Hard alloys are made from 55% W or Mo, 2% C and 26-40% additional metal, consisting partly of Cr.

(2941) Brit. 354,028 (1931). British Thomson-Houston Co., Ltd. and S. L. Hoyt, *Alloy of Carbides*. Alloys consisting of 50 parts WC and 7.5 parts U, balance binder metal are pressed and sintered at 1500-1600° C. (2730-2900° F.).

(2942) Brit. 355,782 (1931). Vereinigte Stahlwerke A. G., *Hard Alloy*. The alloy contains W, Co, Cr, (in which part of the W can be replaced by Mo and part of the Co can be replaced by Ni) and C in form of graphite.

(2943) Brit. 361,363 (1931). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Alloy for Tools.* A sintered alloy for tools comprises at least 2 carbides of W, Mo, B, Si, Ti, Zr, V obtained in the form of solid solutions and an addition of Ni, Co, Cr.

(2944) Czech. 64,566 (1931). Titanit G.m.b.H., *Hard Metal Carbides.* Carbides of W, Ta or Mo are mixed with 15% TiC and binder metal, pressed and sintered.

(2945) French 701,944 (1931). W. L. A. Hasselbach, *Alloys for Tools.* WC and Mo_2C are cemented by electrolytic Fe, Ni, or Co powders.

(2946) French 716,597 (1931). Fried. Krupp A. G., *Carbide Alloys.* The alloys consist of mixtures of B_4C with other carbides of high melting point (over 2000° C.; 3630° F.) and an Fe-group metal, pressed and sintered in vacuum.

(2947) French 716,659 (1931). Bayrische Metallwerke A. G., *Tool Alloys.* The alloys contain C with Si, Zr, Ti, Ce, Th, Cr, Mo, W plus Ni and Co. A typical analysis is Ti 35-45%, Ni 20-30%, Cr 5-10%, W 1-20%, C 6-10%.

(2948) French 718,697 (1931). Fried. Krupp A. G., *Carbide Alloys.* The alloys consist of mixtures of WC with 3-7% C plus 20% of an Fe-group metal like Fe, Ni, Co, plus carbides of V, Cb, Ta (.1-30%), which cause a higher hardness.

(2949) French 720,096 (1931). Fried. Krupp A.G., *Hard Alloys.* Powdered, sintered or molten mixtures of Mo, W, Cr, Ta, V, Zr, B, Si with 5% C. Carbides are sintered under pressure of 150 atmospheres.

(2950) French 721,024 (1931). Fried. Krupp A. G., *Carbide Alloys.* Sintered hard metals consist of a carbide of a high-melting point metal to which other carbides are added plus an Fe-group metal, like Co, Ni, or Fe.

(2951) French 721,766 (1931). Deutsche Edelstahlwerke A. G. and Siemens & Halske A. G., *Hard Metal Alloy.* A hard metal alloy contains more than 50% TiC, Mo_2C, and a carrier metal, such as powdered Fe or Co, in which the TiC is embedded; the mixture is sintered at 1900° C. (3450° F.).

(2952) German 520,139 (1931). Siemens-Schuckertwerke and B. Fetkenheuer, *Hard Alloys.* Carbides of W, Mo, Ti, V, U are mixed with salts of organic acids of Fe, Ni, Co; these latter metals are liberated by reduction, whereupon the alloy is sintered.

(2953) U. S. 1,800,122 (1931). H. Voigtländer and O. Kaufels (Fried. Krupp A. G.), *Producing Articles of Refractory Metal Alloys.* W, and Mo are fused with Ni, Co, Cr, Fe or Si and C, solidified, pulverized, pressed and sintered.

(2954) U. S. S. R. 29,596 (1931). G. Y. Dillon, *Hard Alloys.* Two or more carbides of high-melting metals are cemented with an alloy obtained from Cr and a metal of the Fe-group.

(2955) U. S. S. R. 30,438 (1931). G. A. Meerson, *Hard Alloys From Tungsten and Molybdenum Carbides.* Powdered carbides of the 5th group of elements, *e.g.*, V, Cb, or Ta, are treated as in U. S. S. R. 18,476 (No. 2939).

(2956) Belgian 387,748 (1932). R. Zapp, *Fritted Hard Alloy.* The alloy consists of 30-97% of a double carbide of Cr and W, balance Fe, Cr, V or their carbides or carbonates.

(2957) Brit. 369,854 (1932). Tool Metal Manufacturing Co., *Sintered Hard Metal.* The composition contains VC, plus CbC and 2.5% Fe, and/or Ni.

(2958) Brit. 374,710 (1932). Deutsche Edelstahlwerke A. G. and L. M. Jackson, *Sintered Carbide Alloys.* Alloys of Fe, Co and/or Ni and carbides of Ti, V, Mo, W, U are made by mixing the Fe-group metal in form of a salt of an organic acid (oxalate) with the carbide and reducing the metal from the salt.

(2959) Brit. 376,912 (1932). Fried. Krupp A. G., *Hard Metal Alloy for Tools. Cf:* Austrian 149,197 (No. 3074).

(2960) Brit. 378,055 (1932). T. Kase and K. Honda, *Hard Tool Alloys.* The alloys comprise Ta, W or both together with Mo and Cr or V. C, Ni, Fe are also present.

(2961) Brit. 383,327 (1932). Deutsche Edelstahlwerke A. G. and Siemens & Halske A. G., *Hard Metal Alloy. Cf.:* French 721,766 (No. 2951).

(2962) Brit. 383,387 (1932). P. M. McKenna, *Improvement in Composition of Matter and Process of Manufacturing the Same.* A material, suitable for tools of a mixture of W and/or Mo and a carbide of at least one metal in the 1st column of the 5th group of the periodic table, *e.g.*, V, Cb, or Ta.

(2963) French 726,442 (1932). P. M. McKenna, *Hard Metal.* A sintered hard metal consists of 50 atom % of a monocarbide of Ta, Cb, or V, and of 50 atom % of W or Mo; the mixture is sintered at 2000° C. (3630° F.) under 280 atmospheres.

(2964) French 728,275 (1932). S. A. Union Aciers Fins, *Cemented Carbides.* TiC and ZrC in a ratio of 39:50 are mixed with Ni or Co as binder.

(2965) French 731,317 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Alloys of Carbides.* Alloys of high melting point metal carbides are sintered with auxiliary metals. One procedure involves dissolving 107 g. WO_3 in 400 g. NH_3, adding 49.6 g. $Ni(NO_3)_2$ dissolved in 100 g. water; 18.3 g. C are stirred into this solution and the mixture is evaporated to dryness and sintered.

(2966) French 740,035 (1932). N. V. Molybdenum Co. and J. Oppenheimer, *Aluminum Carbide-Base Hard Alloys.* Al_4C_3 plus a carbide of W, Mo, Ti, Mn, Ta, V, or Zr, are combined with Co and Ni as binder; the total carbide content amounts to 75-97%.

(2967) French 740,275 (1932). N. V. Molybdenum Co. and J. Oppenheimer, *Hard Alloys.* The alloys consist of Al_4C_3 to which other refractory carbides are added, and auxiliary metals, such as Co, Ni, Fe, Cr.

(2968) French 740,684 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Fritted Hard Alloys For Tools.* The alloys contain up to 90% of carbides of Zr or Th and additions of W-, Mo-, Ta-, Ti-carbides, and up to 25% of an auxiliary metal, such as Co, Fe, Ni, Mn.

(2969) German 564,202 (1932). A. Kropf, *Hard Durable Alloys.* The composition contains 5-76% W, 10-50% Ta, 0.5-4% C, and at least 10% Mo, with or without Co, V, Cr, V, Ti, Zr, Si (0.5-20% altogether).

(2970) German 566,996 (1932). Stahlwerke Röchling-Buderus A. G., *Hard Carbide Alloys.* A very hard carbide alloy is made by sintering 100 parts of W, 5-10 parts of ThC_2 and 3-5 parts of Mo in a C crucible to form a complex carbide material.

(2971) Swiss 156,813 (1932). Deutsche Edelstahlwerke A. G., *Hard Metal.* The alloy consists of 50% TiC, to which 10-25% W-, Mo- or Ta-carbide may be added, plus a metal of the Fe-group, and is sintered in a protective atmosphere.

(2972) Swiss 156,814 (1932). Fried. Krupp A. G., *Sintered Vanadium Carbides for Tools. Cf:* German 589,597 (No. 2994).

(2973) Swiss 158,584 (1932). Bayrische Metallwerke A. G., *Sintered Hard Alloy for Tools. Cf:* French 716,659 (No. 2947).

(2974) Swiss 161,898 (1932). Fried. Krupp A. G., *Hard Metal Alloy. Cf.* Brit. 398,932 (No. 2988).

(2975) U. S. 1,840,457 (1932). H. Lohmann, *Tungsten-Tantalum-Carbon-Alloy.* The alloys contain chiefly W and not less than 4% C and some Ta and Mo. The carbides may be used in making the alloy.

(2976) U. S. 1,847,617 (1932). Karl, Prinz zu Löwenstein and W. Müller, *Hard Alloy.* The hard alloy consists of 10-30% Fe, 1-4% C, 64-46% W, 16-11.6% Cr, and 8-5.5% Co.

(2977) U. S. S. R. 31,135 (1932). A. E. Brjuchanow, *Hard Metal Alloy.* The material consists of 50-68% W, 4-15% Mn, 8-12% C, remainder Fe.

(2978) Austrian 132,695 (1933). Poldihütte, *Hard Alloys For Making Cutting Tools.* The alloys contain 2-7% C, 30-50% Co, 22-37% Cr, 7-27% W, 1-20% V, and 8% Fe. W in excess of 17% may be replaced by Mo.

(2979) Austrian 135,049 (1933). Fried. Krupp A. G., *Sintered Hard Alloy.* The alloy consists of $3Cr_3C_2 \cdot W_2C$ and metals, such as Fe, Cr, Va, Ti or their carbides or carbonitrides.

(2980) Brit. 387,684; 387,685 (1933). Bayrische Metallwerke A. G., *Sintered Hard Alloy for Tools. Cf.:* French 716,659 (No. 2947).

(2981) Brit. 389,564 (1933). British Thomson-Houston Co. Ltd. and F. C. Kelley, *Sintered Hard Metal Compositions For Cutting Tool Bits.* Improvement of Brit. 319,698 (No. 2687), 50% TaC and 50% WC are mixed with 13% Co, pressed and sintered in a graphite mold in H_2 at 1400° C. (2550° F.).

(2982) Brit. 390,554 (1933). British Thomson-Houston Co., Ltd., and F. C. Kelley, *Sintered Hard Metal Compositions For Cutting Tool Bits.* The alloys consist of TaC and other carbides of metals of the 6th group of elements and are cemented by 13% of an alloy of 63/37 Fe/Mo composition.

(2983) Brit. 391,984 (1933). Tool Metal Manufacturing Co., Ltd., *Sintered Hard Alloys.* The alloys consist of WC (3-7% C), up to 50% TiC, and up to 25% Fe, Co and/or Ni.

(2984) Brit. 395,134 (1933). Tool Metal Manufacturing Co., Ltd., *Sintered Tool Alloys.* The TiC of Brit. 391,984 (No. 2983) is wholly or partly replaced by another hard Ti-compound.

(2985) Brit. 395,719; 395,721; 395,735 (1933). N. V. Molybdenum Co. and W. W. Triggs, *Hard Alloys for Tools and Tool Parts.* The alloys consist of (*1*) Mo_2C and TiC with Ni and Cr; (2) TiC plus Ni and Cr; (*3*) WC plus Co; or (*4*) WC plus W. To these compositions up to 2% oxides of alkaline earths, and/or Al and Si may be added; glycerol is used for easier molding.

(2986) Brit. 396,129 (1933). British Thomson-Houston Co., Ltd., and F. C. Kelley, *Sintered Hard Metal Compositions.* The alloys consist of CbC, TaC in excess of CbC, and a cement of Co, Fe and Ni and W and/or Mo. For use as tool bits, the cemented double carbide is Cu-brazed to steel.

(2987) Brit. 396,940 (1933). Tool Metal Manufacturing Co., Ltd., *Sintered Zirconium Carbide and Thorium Carbide Alloys.* A sintered heterogeneous mixture, suitable for use as tools consists of ZrC and/or 1-14% ThC_2 plus up to 25% Fe, Co, Ni or Mn, balance W_2C and/or TaC.

(2988) Brit. 398,932 (1933). Fried. Krupp A. G., *Sintered Chromium-Tungsten-Carbon Alloys.* Alloys suitable for use as valves, cutting tools, rayon-spinning nozzles, surgical instruments, etc. comprise 30-97% of the double carbide $3Cr_3C_2 \cdot W_2C$, plus Fe, Cr, V, Ti and their carbides.

(2989) Czech. 62,962 (1933). Poldihütte, *Hard Metal Carbide.* The material consists of a mixture of WC, Ti and C.

(2990) French 743,472 (1933). Firth Sterling Steel Co., *Hard Metal Compositions.* Sintered compositions for tools are composed of fine powders of WC and TaC and either Co, Fe or Ni as binders. A typical composition is 90% W_2C, 5% Ta, 5% Co.

(2991) French 746,209; 746,210; 746,211 (1933). Firth Sterling Steel Co., *Hard Refractory Metals.* The alloys consist of combinations of W-, Ta-, Ti-carbides and Fe, Ni, Co. A mixture of salts of Ti, Zr, Th, V, Ta, Mo, W, U is used as a base.

(2992) French 749,190 (1933). Wolfram & Molybdän A. G., *Hard Alloys For Tools.* The alloys are composed principally of WC with up to 20% cementing Co, Fe, Ni and from 2-50% mixed crystals formed by carbides (or carbides and nitrides); mixed crystals may be composed of TiC-TaC, TiC-CbC, etc.

(2993) French 756,523 (1933). Comp. Lorraine De Charbons Pour L'Électricité, *Hard Alloys.* Up to 80% of the composition is one or more very hard carbides; *e.g.*, 36% WC, 7% TiC and 57% of a hardenable alloy (Fe-W, Co-W or Fe-Co-W).

(2994) German 589,597 (1933). Fried. Krupp A. G., H. Wolff and K. Schröter, *Sintered Vanadium Carbide for Tools.* The alloy consists of VC plus CbC or TaC and a maximum of 25% of Fe, Co or Ni.

(2995) Japan. 102,087 (1933). K. K. Sumitomo Densen Seizojo and H. Kyukichi, *Sintered Hard Alloys.* A mixture of 85-90% WC, 2-5% Cr_3C_2 and 5-10% W or Mo is sintered after compression.

(2996) Swiss 159,719 (1933). Vereinigte Edelstahl A. G., *Formed Bodies of Hard Metal.* The bodies are produced from mixed carbide powders containing at least 39% TiC or ZrC.

(2997) Swiss 161,613 (1933). Fried. Krupp A. G., *Hard Metal Body.* The composition consists of B_4C and an auxiliary carbide with a melting point above 2 000° C. (3630° F.), such asthe carbide of Si, W, Mo and Zr (to reduce the porosity), plus Ni, Fe or Co.

(2998) Swiss 161,896 (1933). Fried. Krupp A. G., *Sintered Hard Metal Alloy.* CbC and TaC or WC are cemented with an auxiliary binder metal.

(2999) Swiss 161,898 (1933). R. Walter, *Chromium-Tungsten Double Carbide Alloys. Cf.:* German 605,108 (No. 3019).

(3000) Swiss 163,062 (1933). Fried. Krupp A. G., *Hard Metal Alloy for Tools. Cf.:* Austrian 149,197 (No. 3074).

(3001) Swiss 164,594 (1933). Fried. Krupp A. G., *Sintered Hard Metal Alloy.* The alloy consists of 90% ZrC and 10% of another high-melting carbide mixed with 25% auxiliary metal as binder.

(3002) U. S. 1,893,144 (1933). A. Kropf (Stahlwerke Röchling-Buderus A. G.), *Tungsten Alloy Suitable for Cutting Tools.* An alloy of high melting point comprises 40-65% W, 10-40% Mo, 1-20% Ta and 1.0-25% C.

(3003) U. S. 1,910,532 (1933). B. Fetkenheuer (Deutsche Edelstahlwerke A. G.), *Hard Metal.* An alloy suitable for tools contains from 60-85% TiC, from 10-20% TaC, and 5-20% of an auxiliary metal, such as Co, Fe or Ni.

(3004) U. S. 1,925,910 (1933). P. Schwarzkopf and I. Hirschl, *Hard Metal Alloys Suitable For Tools.* W-, Mo-, Cr-, Zr-, Ti-carbides plus iron-group metal binder (Fe, Ni, Co) are pressed and sintered.

(3005) Austrian 135,049 (1934). R. Walter, *Chromium-Tungsten Double Carbide Alloys. Cf.:* German 605,108 (No. 3019).

(3006) Austrian 136,839 (1934). Gebr. Böhler & Co., A. G., *Sintered Hard Alloy for Tools.* The alloy consists of 40-50% Zr, 20-30% Co, 5-10% Cr, 10-20% Mo and 4-7% C.

(3007) Austrian 138,245 (1934). N. V. Molybdenum Co. and J. Oppenheimer, *Hard Metal Alloy.* The alloy consists of Al_4C_3, preferrably mixed with carbides of W, Mo, Ti, Ta, Zr, or Si and 3-25% auxiliary metal.

(3008) Austrian 138,248 (1934). Vereinigte Edelstahl A. G., *Hard Alloy for Tools.* Mixed crystals of at least 2 carbides of W, Mo, Ti, Zr, Si, B, V, are alloyed with auxiliary metals and sintered in high-frequency furnace *in vacuo.*

(3009) Austrian 138,620 (1934). Fried. Krupp A. G., *Tool Alloy.* Carbides of high-melting metals are mixed with auxiliary metals, pressed, mechanically worked at high temperatures and sintered.

(3010) Brit. 405,137 (1934). Heraeus Vacuumschmelze A. G. and W. Rohn, *Sintered Hard Alloys.* The alloys contain one or more carbides of W, Mo, Cr, and U and a metal component of higher melting point than that of the carbides, *e.g.*, combinations of WC-W, WC-Ta, etc.

(3011) Brit. 406,012 (1934). N. V. Molybdenum Co. and J. Oppenheimer, *Aluminum-Carbide Base Hard Alloys. Cf.:* French 740,035 (No. 2966).

(3012) Brit. 406,289 (1934). N. V. Molybdenum Co. and J. Oppenheimer, *Hard Metal Tools.* Tools are produced by heat-treating compositions containing W-, Mo-, Ti-, Ta-, V-, Zr-, Si-, Mn-, or Al-carbides and Fe, Ni, Co, Cu, plus Cr, Cd, Mo, Al as hardeners.

(3013) Brit. 407,395 (1934). Firth Sterling Steel Co. and G. J. Comstock, *Sintered Hard Metal Compositions.* A hard sintered composition contains 55-93% WC, 5-30% TaC and 20% of a binding metal.

(3014) Brit. 407,781 (1934). Firth Sterling Steel Co., and G. J. Comstock, *Hard Refractory Metals.* A hard cemented carbide metal contains W-, Ta-, Ti-carbide and Fe, Ni, Co wherein the proportion of WC is greater than the TaC or TiC content.

(3015) French 758,541 (1934). Siemens & Halske A. G., *Hard Sintered Carbide Bodies.* A preformed hard carbide of B, Ti, Si, Zr, Ce or Th or two or more of these plus V, Cb, Ta, Mo, or W is pressed and sintered.

(3016) French 760,155 (1934). Fansteel Products Co. and C. W. Balke, *Hard Alloys for Tools.* The alloys contain 71% WC, 15% TaC, 8% W, 3% Co, 2% Ni, 1% Fe.

(3017) French 773,859 (1934). Comp. Lorraine de Charbons Pour L'Électricité, *Sintered Hard Alloys.* The alloys contain carbides of W and carbides or carbonitrides of Ti bound by an alloy without C of the nature of Stellite.

(3018) German 599,489 (1934). Poldihütte and A. Richter, *Hard Alloys For Making Cutting Tools.* The alloys consist of 2-7% C, 30-50% Co, 22-37% Cr, 7-27% W, 1-20% V and 8% Fe. W in excess of 17% may be replaced by Mo. Composition may also contain 8% Fe.

(3019) German 605,108 (1934). R. Walter, *Chromium-Tungsten Double Carbide Alloys.* Hard alloys are prepared by pressing and sintering a powdered mixture containing 30-95% of $3Cr_3C_2 \cdot W_2C$ with one or more metals of the Fe-group or their carbides or nitrides.

(3020) Swedish 80,532 (1934). Fried. Krupp A. G. and J. Hinnüber, *Sintered Hard Metal Alloy.* The alloy consists of 90% ZrC or ThC_2 with 10% other carbides, and an addition of 25% of auxiliary metal.

(3021) Swiss 167,854 (1934). Wolfram-Molybdän A. G., *Vanadium Alloy for Sand-Blast Nozzles.* A hard alloy is made by sintering VC or mixed crystals of V-Ti-carbides with 25% of Co, Fe or Ni or of a metal of the 6th group of the periodic table, *e.g.*, W, Mo or Cr.

(3022) U. S. 1,959,879 (1934). P. Schwarzkopf, *Production of Hard Metal Alloys Especially For Tools.* Mixed crystals of at least two carbides of refractory metals, *e.g.* W and Ti, are used in combination with an auxiliary metal.

(3023) U. S. 1,960,055 (1934). F. C. Kelley (General Electric Co.), *Cemented Carbides Suitable for Tool Bits, etc.* A sintered composition comprises up to 45% CbC together with TaC plus 3-25% of a cementing medium consisting of up to 50% W or Mo, balance Fe, Co, Ni.

(3024) U. S. 1,961,468 (1934). R. Walter, *Sintered Alloy for Delicate Measuring Instruments, Surgical Instruments, etc.* 30-97% of a Cr-W double carbide compound, 1-60% of a carbide of the 6th periodic series, *e.g.* WC, Mo_2C, plus Fe or Cr are the alloy constituents.

(3025) U. S. 1,973,428 (1934). G. J. Comstock (Firth Sterling Steel Co.), *Hard Metal Composition Suitable For Cutting Tools and Dies.* The alloy contains 35-80% WC, 5-45% TaC, 5-30% TiC, and 1-30% Co, Fe or Ni.

(3026) U. S. 1,973,441 (1934). K. Moers, K. Schröter, and H. Wolff (Fried. Krupp A. G.), *Sintered Hard Metallic Alloys for Use in Forming Implements and Tools.* Sintered hard metallic alloys consist of B_4C with carbides of melting point exceeding 2000° C. (3630° F.) in an amount sufficient to reduce porosity, and metals of lower melting point in an amount sufficient to lower the sintering temperature and to increase toughness and strength.

(3027) U. S. 1,981,719 (1934). G. J. Comstock (Firth Sterling Steel Co.), *Hard Cemented Carbide Material.* An alloy suitable for tools, dies etc. contains 49% WC, 20% TaC, 19% Al_2O_3, and 12% Co, Ni or Fe.

(3028) U. S. 1,982,857 (1934). G. J. Comstock (Firth Sterling Steel Co.), *Hard Cemented Carbide Material.* An alloy suitable for wire-drawing dies, tools, etc., comprises about 46% TiC plus 30% WC, 13% TaC plus 11% Co.

(3029) Brit. 422,961 (1935). Siemens & Halske A. G., *Hard Sintered Carbide Bodies. Cf.:* French 758,541 (No. 3015).

(3030) Brit. 426,506 (1935). Gebr. Böhler & Co., A. G., *Hard Metal Alloys.* Carbides of W, Ti, Cr, V are produced by heating the metal or oxide with C in successive stages, grinding between each state; the carbides and binder are mixed, ground together and sintered.

(3031) Brit. 429,650 (1935). Fansteel Products Co., *Sintered Hard Alloys.* 68-79% WC or W and WC (ratio 12/88), 15% TaC and 5-7% Co, Ni or Fe are sintered in an inert atmosphere.

(3032) Brit. 434,468 (1935). British Thomson-Houston Co., Ltd., *Cemented Hard Refractory Metals.* The production consists of special grinding, mixing and hot-pressing of particles; *e.g.* 75-97% WC ground with 3-25% Co and 75-92% TiC ground with 8-25% Ni are mixed in 90/10 proportion and then hot-pressed.

(3033) Brit. 436,255 (1935). Firth Sterling Steel Co., *Sintered Hard Alloys. Cf.:* Canadian 350,602 (No. 3035).

(3034) Brit. 436,939 (1935). British Thomson-Houston Co., Ltd., *Hard Metal Composition.* The alloy consists of 10-90% carbides of metals of the 6th periodic group, *e.g.*, Cr, Mo, or W, and 10-90% of carbides of metals of the 5th group, *e.g.*, V, Cb, or Ta, and 3-20% Fe, Co, or Ni.

(3035) Canadian 350,602 (1935). Firth Sterling Steel Co. and E. B. Welch, *Sintered Hard Alloys.* An alloy suitable for use as cutting tools and wire-drawing dies contains VC, TiC, Mo, W and 3-15% Al.

(3036) Canadian 354,109 (1935). Firth Sterling Steel Co. and G. J. Comstock, *Cemented Carbide Material.* The alloy comprises 35-80% WC, 5-45% TaC, 0.5-30% TiC plus 5-15% Ni, Co, or Fe. The preferred composition contains 58% WC, 25% TaC and 10% TiC plus 7% binder.

(3037) French 44,449. (Addn.), (1935). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Alloys.* Addition to French 726,718 (No. 3389). 10-90% WC and 10-90% TaC are agglomerated by 3-20% of a more fusible alloy of the Fe- or Mn-group.

(3038) French 779,441 (1935). Vereinigte Edelstahl A. G., *Complex Compounds for Sintered Carbide Tool Material. Cf.:* Swiss 180,113 (No. 3047).

(3039) French 785,576 (1935). Comp. Lorraine De Charbons Pour L'Électricité, *Hard Alloys.* A more fusible auxiliary metal or alloy is fused separately on each of the hard constituents of WC and TiC. The mixed particles are pressed and sintered.

(3040) French 787,010 (1935). Fagersta Bruks A. B., *Cemented Carbide Compositions.* The compositions contain WC, TiC and an auxiliary metal (Co, Ni or Fe) obtained from inorganic compounds, *e.g.*, oxides or carbonates.

(3041) German 608,771; 611,934 (1935). A. Kropf, *Sintered Hard Alloys.* The alloys contain 5-76% W, 10-50% Ta, 20-25% Cr, 0.5-4% C and at least 10% Mo. The Cr may be replaced by Co, Ni or Mn.

(3042) German 621,191 (1935). A. Kropf, *Hard Alloys.* Addition to German 564,202 (No. 2969) and 611,934 (No. 3041). The alloys contain 5-76% W, 10-50% Ta, 0.5-4% C, at least 10% Mo, 20-25% V, Ti, Zr and/or Si. The Mo may be replaced by Ta.

(3043) German 622,347 (1935). Fried. Krupp A. G., C. Agte, K. Schröter, K. Moers and H. Wolff, *Hard Alloys.* The alloys consist of WC with 3-7% C, TiC, plus 25% Fe, Ni, or Co.

(3044) Ital. 329,238 (1935). Deutsche Edelstahlwerke A. G., *Production of Sintered Hard Metals. Cf.:* Austrian 157,679 (No. 3154).

(3045) Swiss 175,076 (1935). Fansteel Products Co., *Hard Alloy for Tools.* The alloy consists of 68-79% WC and 32-21% of an auxiliary metal mixture of TaC and Fe.

(3046) Swiss 176,686 (1935). Vereinigte Edelstahl A. G., *Carbide-Containing Hard Metals.* A carbide of an element of the 3rd and 4th group of the periodic table, *e.g.*, Al, B, Ti or Zr is sintered with a metal of the 5th and 6th group, *e.g.* V, Cb, Mo, W, or Cr, whereby the free metal is partly bound to the carbide and is sintered to give the double-carbide.

(3047) Swiss 180,113 (1935). Vereinigte Edelstahl A. G., *Complex Compounds for Sintered Carbide Tool Material.* The alloys consist of 60-75% WC and W_2C, 10-25% TiC, 1-25% Mo_2C, and 3-25% Fe, Ni, or Co. At least 10% of the total is a solid solution, and at least three of its components are carbides. The mixture is sintered at 1600° C. (2910° F.).

(3048) U. S. 1,991,912 (1935). K. Schröter and H. Wolff (Fried. Krupp A. G.), *Sintered Hard Metallic Alloy for Tools.* The alloy consists of equal parts of VC and CbC with 2.5-5% of Fe or Co as binder.

(3049) U. S. 2,021,576 (1935). P. M. McKenna (Vanadium Alloys Steel Co.), *Unfused Hard Metal Composition for Tools.* The composition consists of TaC, W, and ZrC or HfC, and contains up to 85% TaC, and ZrC or HfC, present as an initial ingredient, to produce the W metal from the WC during the formation of the composition, which occurs by pressing and sintering by high frequency current.

(3050) U. S. 2,023,413; 2,023,414 (1935). B. Fetkenheuer (Deutsche Edelstahlwerke A. G.), *Hard Metal.* The alloy consists of 60-85% TiC, 10-20% hard metal carbide of either W, Mo, or Ta, and remainder an alloy of Co, W or Cr (substantially 40-80% Co, 20-35% Cr and up to 25% W).

(3051) U. S. S. R. 43,157 (1935). G. A. Meerson, *Sintered Carbide of Hard Metal.* A mixture of 75% WC, 13% VaC, 10% Co and 2% Cr is hot-pressed at 100 kg./cm.^{2} (0.7 tsi) at 1480° C. (2700° F.), then sintered in an electric furnace at 1420° C. (2590° F.).

(3052) Austrian 144,572 (1936). Gebr. Böhler & Co., A. G., *Hard Alloys Cemented With Iron Carbide.* WC is combined with up to 30% of a carbide or nitrocarbide of Fe and/or Mn; up to 10% Cu, Cu-Ni, Co, is added as binder.

(3053) Austrian 144,828 (1936). Gebr. Böhler & Co., *Hard Metal Alloy. Cf.:* Brit. 426,506 (No. 3030).

(3054) Austrian 145,802 (1936). Vereinigte Edelstahl A. G., *Sintered Hard Metal for Tools.* A mixture of finely divided powdered W and/or Mo with several carbides of Ta, Cb, or V is pressed under high frequency eddy currents.

(3055) Austrian 148,598 (1936). Fried. Krupp A. G., *Sintered Vanadium Carbide for Tools. Cf.:* German 589,597 (No. 2994).

(3056) Brit. 443,303 (1936). Firth Sterling Steel Co. and A. H. Stevens, *Sintered Hard Metal Composition.* Addition to Brit. 407,781 (No. 3014). The hard cemented carbide material contains TiC in an amount exceeding 30% and lesser amounts of WC and TaC.

(3057) Brit. 444,724 (1936). K. M. Tigerschiöld and K. Bonthron, *Sintered Hard Alloys.* Hard compounds of refractory metal carbides are mixed with an inorganic compound of Fe, Co, Ni, pressed and sintered.

(3058) Brit. 453,824 (1936). Vereinigte Edelstahl A. G., *Complex Compounds for Sintered Carbide Tool Material. Cf.:* Swiss 180,113 (No. 3047).

(3059) Canadian 358,916 (1936). P. Schwarzkopf, *Hard Metal Alloy.* The alloy is composed of at least three carbides and an auxiliary metal; from 50 to 80% of the total composition consists of solid solution carbides, the balance of the auxiliary metal.

(3060) Danish 51,354 (1936). Vereinigte Edelstahl A. G., *Hard Metal Alloy. Cf.:* Swiss 159,719 (No. 2996).

(3061) French 800,554 (1936). Union Aciers Fin S. A., *Hard Metal Tool.* The alloy consists of 50-60% W, 2-6% C, 2-6% Ti, 5-15% Cr, 25-40% Fe, and has a Rockwell hardness of 84-86.

(3062) French 802,602 (1936). P. Scholtes, *Hard Metal Bodies.* The alloy consists of 69% W, 15% Ti, 2% Ta, 10% C and 3% Co.

(3063) Norw. 56,118 (1936). Vereinigte Edelstahl A. G., *Hard Metal Alloy.* The alloy consists of more than 65% TiC and remainder WC mixed with up to 20% Mo_2C or TaC.

(3064) Swedish 86,962 (1936). Vereinigte Edelstahl A. G. and B. Fetkenheuer, *Production of Sintered Hard Metal.* The alloy consists of 85-95% TiC, WC, Mo_2C and/or TaC and 15-5% Co, Ni or Fe.

(3065) Swedish 87,299 (1936). Fagersta Bruks A. B., K. M. Tigerschiöld and K. Bonthron, *Production of Complex Carbides.* Double carbides and solid solutions of two or more carbides are obtained by reduction of oxides in the presence of C.

(3066) Swiss 180,113 (1936). Vereinigte Edelstahl A. G., *Sintered Hard Metal for Tools.* The material consists of three different metal carbides and 5-25% binder sintered at 1600° C. (2910° F.).

(3067) U. S. 2,026,958 (1936). K. Becker, K. Schröter and H. Wolff (General Electric Co.), *Sintered Hard Metallic Alloys.* The alloys consist of WC and VC plus 20% Fe, Ni or Co, and up to 30% VC.

(3068) U. S. 2,033,513 (1936). G. J. Comstock (Firth Sterling Steel Co.), *Cemented Carbide Material.* The alloy contains 55-75% WC or Mo_2C, 15-33% TaC, 0.5-25% Co, Ni or Fe and 0.1-10% TiO_2 or ZrO_2.

(3069) U. S. 2,040,592 (1936). K. Becker (Wolfram & Molybdän A. G.), *Hard Alloys For Tools.* The alloys consist of 50% WC, 2-30% of hard mixed crystals of carbides of metals of the 4th or 5th groups of the periodic table, *e.g.* Ti, Zr, V, Cb, Ta, and 25% Fe with B.

(3070) U. S. 2,048,239 (1936). R. T. Wirth, *Sintered Hard Alloy.* The alloy consists of double carbides of W and Cr and analyzes 8.5-9% C, 55-60% Cr, 32-36% W.

(3071) U. S. 2,048,706 (1936). R. T. Wirth, *Chromium-Tungsten-Carbon Alloys.* A sintered carbide alloy contains 8.5-9.0% C, 55-60% Cr, and 32-36% W.

(3072) U. S. 2,049,317 (1936). R. Pinta (General Electric Co.), *Sintered Tungsten- and Titanium-Carbide Composition.* Ni powder is absorbed by TiC, and Co powder is separately absorbed by WC. The materials are then homogeneously mixed and sintered.

(3073) U. S. 2,051,972 (1936). K. M. Tigerschiöld and K. Bonthron, *Process of Producing Hard Metal Alloys.* A process for producing sintered hard metal alloys comprises mixing WC, TiC or TaC with one or more inorganic compounds of an auxiliary metal.

(3074) Austrian 149,197 (1937). Fried. Krupp A. G., *Hard Metal Alloy for Tools.* The alloy consists of 50% WC with 3-7% C, up to 30% VC or TaC, or both, and up to 20% Fe, Co, or Ni.

(3075) Austrian 149,558 (1937). Gebr. Böhler & Co., A. G., *Sintered Hard Alloys.* The alloys consist of TiC and one or more metals of the 6th group of the periodic table, *e.g.* W, Mo, or Cr, or their carbides, plus low melting metals like Co, Ni, Cu; the carbide particles are first coated with the lower melting metal, and 1-3% NaF or boric acid may be added, which evaporates during sintering under high pressure.

(3076) Austrian 150,281 (1937). Comp. Française pour L'Exploitation des Procédés Thomson-Houston, *Sintered Hard Alloys.* Two different hard metal carbides are each mixed with auxiliary metals by adsorption, and the products are then mixed and sintered.

(3077) Austrian 151,279 (1937). Vereinigte Edelstahl A. G., *Hard Metals.* The manufacture of hard metals comprises first producing single carbides of Ti, B, Th, Zr, or Ce and then mixing them with Ta, Mo, or W in elementary powdered form to produce double carbides.

(3078) Brit. 460,013 (1937). British Thomson-Houston Co. Ltd., *Hard Carbide Compositions.* Sintered alloys consist of equal portions of Mo_2C and VC with or without Fe, Ni, or Co.

(3079) Brit. 463,239 (1937). British Thomson-Houston Co. Ltd., *Sintered Refractory Alloys.* The alloys are composed of 1-5% of Ta-, Mo-, Cb-, and Ti-carbides and 95-99% of WC, without a lower melting metal. The powders are mixed in a grinding mill, compressed and sintered in a reducing atmosphere.

(3080) Brit. 465,323 (1937). Fried. Krupp A. G., *Sintered Hard Alloys.* The alloys consist of 0.5-20% Co, Ni, Fe and/or Mn as binder, and 3-20% TiC, 0.3-10% VC, and WC as the main constituent. Alloys of Co, Ni, Fe, Mn with Mo, W or Cr can also be used as binder metal.

(3081) Brit. 471,784 (1937). Siemens & Halske A. G., *Sintered Cutting Alloys.* The alloys are composed of 80% WC plus TiC,(the latter in very small proportion only) plus 20% Co or Ni. Materials similar to Stellite may be used as cementing metals.

(3082) Brit. 471,966 (1937). Vereinigte Edelstahl A. G., *Sintered Hard Alloy For Tools.* The alloy consists of 50-70% of W or Mo, 2-6% C, 5-15% Cr, and a cementing metal of the Fe-group, with 0.6% Ti, Zr, Si and/or B, totalling 20%, which may also be added as carbides.

(3083) Canadian 368,917 (1937). Ramet Corp. of America and C. W. Balke, *Sintered Tungsten-Tantalum-Carbon Alloy.* The alloy is composed of 50-90% WC, 10-50% TaC and 13-20% of a suitable binder, such as Fe, Co, or Ni.

(3084) French 808,096 (1937). Soc. Industrielle et Commerciale Des Aciers and Fried. Krupp, A. G., *Hard Alloys.* The alloys consist of 3-30% TiC, 0.3-10% VC, 0.5-20% Ni, Fe or Mn, and remainder WC.

(3085) French 811,243 (1937). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Refractory Alloys of Great Hardness.* The alloys are obtained by associating the carbides in eutectic proportions; thus in the case of the systems VC and Mo_2C, the eutectic composition is 50/50 by weight.

(3086) French 811,283 (1937). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Cemented Refractory Alloy.* A hard alloy is made by agglomerating WC with less than 5% of a carbide of Ti, Ta, Mo or Cb. CbC as cementing alloy does not react with WC at high sintering temperatures.

(3087) French 816,840 (1937). Keramet G.m.b.H., *Metal Carbides.* Mixtures of carbides of W, Ti, V, Cr, Ta, Mo are formed directly from mixtures of the metals which are carburized, then pressed and sintered.

(3088) French 818,753 (1937). Rheinmetall-Borsig A. G., *Production of Refractory Carbides.* W and Cr powders are mixed with titanic and vanadic acids and free C. The mixture is shaped, presintered to reduce V and Ti compounds, and finally sintered at high temperature.

(3089) German 650,071 (1937). Fried. Krupp A. G. and K. Moers, *Hard Alloy Articles.* 1-5% TiC is mixed with 25-40% Co, Ni or Fe, remainder WC or Mo_2C, and sintered for the production of sheets or wires.

(3090) German 654,829 (1937). W. Müller, *Hard Alloy For Tools.* The alloy consists of 2-9.5% Be, 0.5-2% C and the rest W, Mo, or Cr or an alloy of these. The alloy may contain 1-15% of Fe, Co, Ni or Ti; the Be content must be twice as much as C.

(3091) Italian 351,669 (1937). Rheinmetall-Borsig A. G., *Refractory Carbides. Cf.:* French 818,753 (No. 3088).

(3092) Swiss 189,695 (1937). Fried. Krupp A. G., *Sintered Hard Metal Alloy.* The alloy consists of 3-30% TiC, 0.3-10% VC, rest WC, and 0.5-20% auxiliary metal; the TiC content is larger than the VC content.

(3093) U. S. 2,075,742 (1937). K. Moers (General Electric Co.), *Shaped Bodies From Tungsten or Molybdenum Carbides.* Bodies are produced by pressing, sintering and mechanical working of an alloy containing 25-40% of a metal of the Fe-group, 1-5% TiC, remainder WC or Mo_2C.

(3094) U. S. 2,076,366 (1937). H. S. Cooper (General Electric Co.), *Hard Carbide Composition.* A cast or sintered alloy is produced from a mixture of VC (containing 18% C) and Mo_2C (containing 6% C); this mixture is liquid at 2475° C. (4485° F.), while its constituents melt at higher temperatures. In case of the sintered alloy, the double carbide is mixed with Ni, Co or Fe, pressed and heated, until the binder metal melts.

(3095) U. S. 2,081,049 (1937). H. S. Cooper (General Electric Co.), *Sintered Hard Carbide Composition.* The alloy contains 99% WC, and 1% Cb-, Ti-, Mo- or Ta-carbide.

(3096) U. S. 2,091,017 (1937). P. Schwarzkopf, *Sintered Hard Tool Alloy.* A tool alloy consists of 50-70% of WC and 20-40% Mo_2C combined into mixed crystals of great hardness, and 20% of a metal of the Fe-group.

(3097) U. S. 2,093,844; 2,093,845 (1937). P. M. McKenna, *Production of Hard Composition for Tools and Dies.* The alloy is composed of 7-13% W, 12-15% Ni and 68-78% of a comminuted macro-crystalline multi-carbide, consisting of TaC with 2-8% ZrC and 4-16% CbC.

(3098) U. S. S. R. 51,577 (1937). G. Y. Dillon, *Hard Alloys.* WC and other metal carbides are cemented with a metal of the Fe-group, *e.g.* Co; 7.5-33% of TiC may be incorporated.

(3099) Austrian 152,283 (1938). Deutsche Edelstahlwerke A. G., *Hard Alloy.* The alloy consists of at least 66% TiC and 20% of an auxiliary metal, and, optionally, a second refractory metal carbide.

(3100) Austrian 153,484 (1938). Fried. Krupp A. G., *Hard Metal Alloys.* Consists of WC with 3-30% TiC plus 0.3-10% VC and up to 20% auxiliary metal.

(3101) Austrian 153,790; 153,791 (1938). Allgemeine Elektrizitäts Gesellschaft, *Hard Metal Alloy.* The alloy consists of 40% TaC, rest CbC or WC plus a Fe-metal binder.

(3102) Brit. 477,572 (1938). Fédam S. A., *Molded Article of Hard Alloys.* A mixture of 1% Ba-bronze, 5% Co, 18% TiC and 76% WC is ball-milled, placed in a graphite mold, heated in CO_2 to drive out air; then pressed and heated.

(3103) Brit. 481,876 (1938). Keramet G.m.b.H., *Hard Alloys.* A hard alloy consists of two metal carbides, *e.g.* WC-TiC, embedded in a mass of mixed crystals consisting of a solid solution of the same metal carbides in one another without other binder agents.

(3104) Brit. 491,722 (1938). Rheinmetall-Borsig A. G. and G. Boecker, *Sintered Hard Articles.* A mixture of raw material comprises compounds of high melting point, such as WC or Cr_3C_2 plus oxides of a high melting point but tough metal, such as Ti or V together with C.

(3105) Brit. 494,661 (1938). Tool Metal Manufacturing Co., *Hard Metal Alloys.* The alloy consists of 30-50% Fe, 2-10% Cr and remainder a mixture of 1:2 of TiC and WC.

(3106) Brit. 495,678 (1938). Vereinigte Edelstahl A. G., *Hard Alloys.* A hard alloy consists of 50-93% TaC, 5-30% TiC and 2-20% Fe.

(3107) French 827,627 (1938). C. A. Bolton, *Hard Metals and Substances.* Refractory carbides are used with refractory metals to form mixed crystals, instead of the customary binders.

(3108) French 827,811 (1938). Vereinigte Edelstahl A. G., *Hard Metal Alloys.* The alloys contain Ti-, Ta-, Cb-, Mo- and W-carbides and an auxiliary metal; a typical composition is 0.5-30% TiC, 2.5-20% TaC, 2.5-20% CbC and 2-20% auxiliary metal.

(3109) French 828,550 (1938). Vereinigte Edelstahl A. G., *Hard Metal Alloys. Cf.:* Brit. 495,678 (No. 3106).

(3110) French 833,748 (1938). G. J. Comstock, *Hard Alloys.* Compositions such as 87% WC, 7% Ni, and 6% Ag or 87% TiC, 9% Ni, and 4% Zn are mixed, heated at 1100-1350° C. (2010-2460° F.) and pressed at 4000 kg./cm.^{2} (30 tsi.).

(3111) German 659,534 (1938). Siemens & Halske A. G. and E. Burrow, *Hard Alloy.* Carbides of W, Ti, V, Mo and U, mixed with Fe, Co or Ni, are sintered with 0.1-0.2% Si present.

(3112) German 661,842 (1938). Deutsche Edelstahlwerke A. G. and R. Kieffer, *Hard Metals.* A method of producing hard metal bodies comprises reducing and carburizing ores, such as wolframite or tantalite with an addition of C, using a very high temperature to produce the hard metals in one operation; the hard metal is first in a plastic state. After cooling the body is crushed and powdered.

(3113) German 662,058 (1938). Firth Sterling Steel Co., *Hard Metal Composition Suitable for Tools. Cf.:* U. S. 1,973,428 (No. 3025).

(3114) German 668,861 (1938). Fried. Krupp A. G. and K. Becker, H. Wolff and K. Schröter, *Hard Metal Alloy.* A sintered hard metal alloy consists of 30% VC, or TaC mixed with 20% Fe, Ni or Co, remainder WC with 3-7% C.

(3115) Italian 363,198 (1938). A. Brezzi, *Double Carbide.* The alloy consists of 73% WC, 17% TiC, and 10% auxiliary metal.

(3116) U. S. 2,107,122 (1938). C. A. Laise, *Hard Metal Composition Suitable for Cutting Tools.* Carburized alloys containing W, Co, Cr, Th and Fe are used for tools.

(3117) U. S. 2,113,353; 2,113,354 (1938). P. M. McKenna, *Tungsten-Titanium-Carbide.* A new carbide substance, $WTiC_2$, is prepared by heating W with Ti in the presence of C in a menstruum metal.

(3118) U. S. 2,113,355 (1938). P. M. McKenna, *Hard Composition of Matter.* A new carbide compound for cutting points consists of particles of $WTiC_2$ cemented in a matrix together with other carbides.

(3119) U. S. 2,113,356 (1938). P. M. McKenna, *Process of Making Hard Compositions of Matter.* A composition for cutting points for tools contains $WTiC_2$ and

a binder which is heated under reduced pressure in the presence of Mg to a temperature exceeding 1350° C. (2460° F.).

(3120) U. S. 2,122,157 (1938). P. Schwarzkopf (American Cutting Alloys Inc.), *Hard Metal Alloy.* The alloy consists of 60-75% WC and W_2C, 10-25% TiC, 1-25% Mo_2C, and 3-25% of auxiliary metal.

(3121) U. S. 2,123,574; 2,123,575; 2,123,576 (1938). P. M. McKenna, *Hard Composition Suitable For Dies and Cutting Tools.* Powdered TaC and CbC, TiC or WC are embedded in a matrix of W or Mo.

(3122) U. S. 2,124,020 (1938). R. T. Wirth, *Chromium-Tungsten Alloys.* Hard sintered alloys which are suitable for cutting tools contain 12.5-15% Cr, 75-80% W, and 6.5-7% C.

(3123) U. S. 2,124,509 (1938). P. M. McKenna, *Carbides of Tantalum.* Products of the reaction between Ta and Cb and C are produced in the presence of a molten metallic menstruum differing from the reactants.

(3124) U. S. 2,128,146 (1938). J. Hinnüber (General Electric Co.), *Sintered Hard Alloys for Machining Tools.* The alloy contains 5.5% Co, 16% TiC, 1% VC and the remainder WC.

(3125) U. S. 2,133,867 (1938). G. Lucas (General Electric Co.), *Cemented Carbide Composition Suitable for Dies and Cutting Tools.* A cemented carbide composition contains less than 1% Cr_3C_2, 2-25% Co and remainder a carbide of the W-group.

(3126) Austrian 155,555 (1939). Fansteel Products Co., *Hard Alloy.* A mixture of 68-79% WC, 5-7% of a Fe-group metal, 3-10% W, and remainder TaC is sintered in a protective atmosphere.

(3127) Austrian 156,495 (1939). Titanit G.m.b.H., *Tip Welded on Tool Holder.* The tip consists of a sintered body of a mixture of 50-65% W, 5-15% Cr, 2-6% C and 6% Ti, Zr, Si or B.

(3128) Austrian 157,088 (1939). Fried. Krupp, A. G., *Sintered Hard Metal Alloy.* The body consists of 85% CbC, 10% TaC, and 5% Co., or 40% CbC, 20% TaC, 30% WC, and 10% Co.

(3129) Austrian 157,379 (1939). Fried. Krupp, A. G., *Hard Metal Alloy.* WC-powder is mixed with 40% TiC and 25% Fe, Ni or Co powder, pressed and sintered.

(3130) Belgian 431,562; 431,573 (1939). P. M. McKenna, *Hard Metal Alloy.* Powders of WC and TiC are mixed and cast at 1300° C. (2370° F.) in the presence of Mg.

(3131) Brit. 499,763 (1939). C. A. Bolton and J. G. Boecker, *Production of Hard Alloys. Cf.:* U. S. 2,173,749 (No. 3153).

(3132) Brit. 499,789 (1939). C. A. Laise and M. F. Rogers, *Hard Alloys.* A carburized alloy of WC or TiC containing 2.5% VC is mixed with a bonding medium of an alloy of V and Co.

(3133) Brit. 508,662 (1939). British Thomson-Houston Co. Ltd. and Tool Metal Manufacturing Co. Ltd., *Hard Alloys. Cf.:* French 848,644 (No. 3138).

(3134) Brit. 514,035 (1939). P. M. McKenna, *Method of Preparing Metal Carbide Compositions.* The preparation entails heating a mixture of hard carbides and a metallic binder in the presence of Mg as a reducing agent under sub-atmospheric pressure to a temperature sufficient to melt the binder.

(3135) Canadian 389,423 (1939). Canadian General Electric Co., Ltd., *Cemented Carbide Composition.* A sintered composition contains 0.25-0.50% Cr_3C_2, 2-25% Co with the remainder consisting of a mixture of WC and TaC.

(3136) French 837,896 (1939). Fried. Krupp A. G., *Hard Alloys.* 30-35% TiC, 25-30% WC, 5% Cr, 25% Co, 5% Ni, and 10% Fe are sintered and tempered in oil.

(3137) French 846,617; 846,618; 846,619 (1939). P. M. McKenna, *Double Carbides of Tungsten and Titanium.* $WTiC_2$ is produced by the reaction of powdered W and Ti with C in a bath of molten Ni or Co.

(3138) French 848,644 (1939). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys.* A mixture of more than 50% of WC and TaC and the remainder consisting of one or more carbides of Ti, Mo, Zr, or Th are pressed and sintered at 1400-1700° C. (2550-3100° F.).

(3139) French 850,580 (1939). Le Carbone-Lorraine, S. A., *Hard Alloys.* WC and Mo_2C and auxiliary metals are homogenized and fritted.

(3140) German 673,814 (1939). Heraeus Vacuumschmelze A. G., *Production of Sintered Hard Metal Bodies.* Addition to German 666,720 (No. 3424). WC or Mo_2C is the major ingredient, and ZrC is used as binder.

(3141) German 681,743 (1939). Poldihütte, *Hard Metals.* The alloy consists of WC plus TiC, the latter being added in form of metallic Ti plus the stoichiometric equivalent of C; the Ti (0.5-15%) is added in an excess of 0.1-5% over the C.

(3142) Swedish 95,834 (1939). Neue Telephongesellschaft m.b.H. and G. Ritzau, *Production of Sintered Hard Alloys.* A mixture of 91-94% of carbides of W, Mo, Ti or Ta, 5-7% Co, 0.3-1% W, 0.5-2% Cr and 0.05-0.2% C is pressed and sintered.

(3143) Swedish 96,544 (1939). Deutsche Edelstahlwerke A. G. and R. Kieffer, *Hard Metal Alloy.* A hard metal alloy is claimed of the following composition: 50-93% TaC or CbC or a mixture thereof, preferably in the form of a solid solution, 5-30% TiC and 2-20% metals of the Fe-group.

(3144) Swedish 97,484 (1939). Deutsche Edelstahlwerke A. G., and P. Schwarzkopf and I. Hirschl, *Sintered Hard Metal.* A sintered hard metal consists of 39-75% TiC, 15-50% Mo_2C and/or WC, plus 8-22% auxiliary metals such as Ni, Co, and/or Cr, in which the carbides are present in the form of solid solutions.

(3145) Swiss 207,102 (1939). Deutsche Edelstahlwerke A. G., *Hard Metal Alloy.* The alloy consists of 5-30% TiC, 50-93% of a carbide of the 5th group of the periodic system, *e.g.* V, Cb, or Ta, and 2-20% of a metal of the Fe-group.

(3146) U. S. 2,162,574 (1939). W. Dawihl and K. Schröter (General Electric Co.), *Hard Metal Alloys Suitable for Tools.* A hard metal alloy contains 30-50% Fe, 2-10% Cr, and the remainder TiC and WC in a ratio of 1:2.

(3147) U. S. 2,166,795 (1939). R. Chelius (General Electric Co.), *Sintered Hard Composition for Machining Hard Castings.* A sintered hard alloy contains 0.5-3% VC, 0.25-1.5% Mo_2C and 8% auxiliary metal, such as Co or Fe, in a mixture with WC.

(3148) U. S. 2,167,516 (1939). F. C. Kelley (General Electric Co.), *Sintered Hard Metal Composition.* The alloy consists essentially of from 75-90% WC, 5-25% TaC and 2-20% binder of a metal of the Fe-group.

(3149) U. S. 2,169,090 (1939). W. Dawihl and K. Schröter (General Electric Co.), *Sintered Hard Compositions for Tools.* A sintered hard metal alloy consists of a mixture of WC, 5-20% TiC, 0.5-2% VC, 0.5-2% Mo_2C, and 6-12% of a metal of low melting point.

(3150) U. S. 2,170,432 (1939). P. Schwarzkopf (American Cutting Alloys Inc.), *Hard Alloy for Tools.* The alloy is produced by sintering from a mixture of two refractory carbides in a ratio of 1:1 or 1:3 with 2.6% Fe, to yield mixed crystals of greatest hardness.

(3151) U. S. 2,170,433 (1939). P. Schwarzkopf (American Cutting Alloys Inc.), *Hard Alloy for Tools.* The alloy is produced from a mixture containing two refractory carbides in a ratio of 1:1 or 1:3 with 3-22% Fe-metal, by shaping the mixture and alloying it by sintering at 1400-1600° C. (2550-2910° F.) until mixed crystals are formed.

(3152) U. S. 2,171,391 (1939). A. Boecker (Duradur S. A.), *Process of Producing Hard Materials.* Pulverized W and HVO_3 is mixed with 8-13% C, and heated at 1500-2000° C. (2730-3630° F.); the finely pulverized product is then shaped and re-heated at 1500-2000° C. (2730-3630° F.).

(3153) U. S. 2,173,749 (1939). J. G. Boecker and G. Boecker (C. A. Bolton), *Preparation of Hard Metals.* Mixed carbides, such as WC, CbC, and VC, are subjected to heat treatment at progressively increasing temperatures in stages; the temperature stages correspond to temperatures at which the individual constituents most readily combine.

(3154) Austrian 157,679 (1940). Deutsche Edelstahlwerke A. G., *Production of Sintered Hard Metals.* Carbides of metals of two different groups of the periodic system are mixed and heated, to form mixed crystals which are crushed, mixed with auxiliary metal, and sintered.

(3155) Brit. 528,565 (1940). Cutanit, Ltd., *Hard Metal Alloy.* The alloy consists of WC plus 1.8-4.5% TiC and 9-15% Co, Ni or Fe.

(3156) Canadian 391,617 (1940). Canadian General Electric Co., Ltd., *Sintered Hard Alloy.* The alloy consists of 1% VC, 0.5% Mo_2C, 6% Co, and balance WC.

(3157) French 855,282 (1940). Deutsche Edelstahlwerke, A. G., *Hard Metal Alloy.* The alloy consists of 2.5-6% TiC, 9-15% Fe, Ni or Co, and balance WC.

(3158) German 699,116 (1940). Meutsch, Voigtländer & Co., *Articles from Cemented Carbides.* A Co alloy saturated with W or WC is proposed as the auxiliary metal for cementing carbides, *i.e.* an alloy with a eutectic of approximately 45% W, melting at 1480° C. (2710° F.). The cementing agent can be used either in molten form or powdered and mixed with the carbides of other refractory metals.

(3159) Swiss 207,753 (1940). F. Eisner, *Method for the Production of Hard Metal.* A mixture of 80% WC, 17.7% Zr, and 2.3% C is pressed and sintered at 2000° C. (3630° F.), above the melting point of Zr, which acts as the auxiliary metal, and forms ZrC.

(3160) U. S. 2,188,983 (1940). H. N. Padowicz (Sirian Wire & Contact Co.), *Hard Metal Alloys and Process of Making Same.* A hard metal alloy consisting of three finely divided carbides from W, U, and Cr, are cemented together by an Fe-group metal and sintered.

(3161) U. S. 2,191,446 (1940). C. W. Balke, F. L. Hunter and R. A. Haskell (Fansteel Metallurgical Corp.), *Hard Metal.* The alloy consists of 30-60% metals of the Fe-group, 5-30% Cr, and 15-50% of W or an equivalent amount of Mo, Ta, Cb, Ti, or Zr equal to the molecular equivalent of 15-50% Ta, and 1-3% C.

(3162) U. S. 2,196,009 (1940). W. Dawihl and K. Schröter (General Electric Co.), *Hard Alloys Suitable for Dies or Metal Cutting Tools.* An alloy consists of WC and TaC amounting together to over 50%, and over 5% of at least one carbide of Ti, Mo, V, Cb, Zr or Th; it is sintered at 1400-1700° C. (2550-3100° F.).

(3163) U. S. 2,198,343 (1940). R. Kieffer (American Cutting Alloys Inc.), *Hard Metal Composition.* A sintered hard metal alloy for tools comprises 60% TaC, 5% TiC, 11% CbC, 20% WC, and 4% of an auxiliary Fe-group metal.

(3164) U. S. 2,202,821 (1940). C. W. Balke (Ramet Corp. of America), *Hard Metal Alloy.* A sintered composition contains 15-31% of binder metal, including Fe-group metals, 79-10% WC, and 14-80% TaC.

(3165) U. S. 2,225,152 (1940). J. A. Boyer and C. G. Rose (The Carborundum Co.), *Hard Carbide Composition.* A fused carbide composition consists of 15% B_4C and TiC, which latter is present as a separate crystalline phase solidified from a fused mass.

(3166) Austrian 160,172 (1941). Deutsche Edelstahlwerke A.G., *Hard Metal for Tool Parts.* The material consists of mixed crystals containing 39-90% carbides of metals of the 4th group of the periodic system and up to 30% carbides of the 6th group; an example is 55-70% ZrC or TiC, 15-30% Mo_2C, and 8-15% Ni.

(3167) Austrian 160,276 (1941). Deutsche Edelstahlwerke A. G., *Hard Metal Alloy.* The alloy consists of 50-93% TaC and 5-30% TiC, remainder Fe and Co.

(3168) Brit. 531,855 (1941). Tool Metal Manufacturing Co., Ltd., *Sintered Hard Alloys.* The alloy is composed of WC and 0.5-3% VC, 0.25-1.5% Mo_2C, and 3-8% of an auxiliary Fe-group metal.

(3169) Brit. 532,099 (1941). Cutanit, Ltd., *Hard Metal Alloys.* The composition of the alloy is 9-15% Fe-group metal, 4.5-8% TiC and balance WC.

(3170) French 863,493 (1941). E. Looser, *Alloy for Tools.* The alloy consists of W, Mo, Cr, Co, Ta and 0.5-3% C, and is sintered at 1700-2000° C. (3090-3630° F.).

(3171) French 866,889 (1941). L. Renault, *Hard Carbide Alloy.* The alloy is composed of a mixture of WC and W_2C in such proportions that the C content is 5.6-5.9%.

(3172) German 714,374 (1941). Fried. Krupp A. G. and R. Chelius, *Alloy for Cutting Tools.* A sintered alloy of WC contains VC (0.5-3%), Mo_2C (0.25-1.5%) and Co, Fe, Ni (3-8%), and is suitable for making tools.

(3173) Italian 390,188 (1941). R. Zapp, *Hard Metal Carbide.* Mo powder is mixed with C and 10% WC or TiC and heated in an atmosphere containing C.

(3174) U. S. 2,246,387 (1941). P. Schwarzkopf (American Cutting Alloys Inc.), *Carbide Composition for Cutting Tools.* A sintered hard metal composition for cutting tools consists of 4% TiC and 86% WC to form a monophasic crystal structure and an addition of 10% Fe.

(3175) U. S. 2,253,969 (1941). W. Dawihl and A. Fehse (General Electric Co.), *Hard Metal Bearing Materials.* The alloys consist of 30-95% cemented WC and 5-70% of a carbide of Ti, Zr, V, Cb or Cr.

(3176) U. S. 2,265,010 (1941). P. Schwarzkopf (American Cutting Alloys Inc.), *Cemented Hard Materials Suitable for Tools such as Those for Cutting or Drilling.* The alloys consist of 58-76% WC, 16-25% Ti and 3-22% Co or Ni.

(3177) U. S. S. R. 58,706 (1941). G. A. Meerson, *Hard Alloys.* A fine-grained TiC composition containing up to 17% C is made by heating TiO_2 to incandescence with an excess of C-black, adding W or Mo and heating to 1400-1800°C. (2550-3270° F.), whereby multiple carbides are formed.

(3178) Belgian 444,498 (1942). Harta A. G., *Fritted Hard-Metal Alloy.* The alloy contains 30-80% Fe_3C saturated with Mn_3C and B_4C and 70-20% of at least one metal of the 4th, 5th and 6th group of periodic table.

(3179) Belgian 445,007 (1942). S. A. Le Carbone-Lorraine, *New Hard Fritted Alloys.* A pulverized reducible compound of metal to be carburized is mixed with pulverized reducible compound of Cr and V and with a reducible compound of an auxiliary metal. The mixture is reduced in a carburizing atmosphere, pressed and sintered.

(3180) Belgian 445,910 (1942). S. A. Le Carbone-Lorraine, *Solid Solutions of Metal Carbides.* At least one of the carbides is prepared in the presence of other carbides in which it diffuses in nascent state. Carbides are prepared from fine powders with reducible compounds of the refractory carbide metal and are heated, reduced and carburized simultaneously with finely divided C.

(3181) Belgian 445,727 (1942). S. A. Le Carbone-Lorraine, *New Hard Fritted Alloys.* The alloy consists of a double carbide of Ti and W, plus ZrC and CbC. The ZrC is introduced into the alloy in the form of a solid solution. The finely powdered product is mixed with other constituents, pressed and sintered.

(3182) Belgian 446,481 (1942). S. A. Le Carbone-Lorraine, *Refining Refractory Carbides.* WC and/or Mo_2C is incorporated with carbides to be refined; the operation is carried out at high temperature in the presence of a flux and a quantity of free C.

(3183) German 720,502 (1942). Deutsche Edelstahlwerke A. G. and P. Schwarzkopf, *Hard Metal Alloys for Tools.* A sintered alloy contains 3-20% of one or more metals of the group of Ni, Cr, Co, and the remainder consisting of at least two carbides of W, Ti, Mo, Zr, Si, B, or V.

(3184) Swiss 218,139 (1942). Fried. Krupp A. G., *Hard Metal Body for Boring Tools.* The body consists of a matrix of a carbide of a metal of the 6th periodic group, *e.g.* Cr, Mo, or W with 20% of a metal of the Fe-group, in which are embedded hard metal pieces, 0.1 mm in size, of a greater hardness and higher sintering temperature than the matrix.

(3185) U. S. 2,289,104 (1942). K. Schröter and W. Dawihl (General Electric Co.), *Solid Solutions Suitable for Tools of High-Cutting Capacity.* TiO_2 is heated in an atmosphere of N_2 in the presence of C; the resulting TiN is heated with WC and C in a reducing atmosphere to produce a solid solution multicarbide material.

(3186) Czech. 72,338 (1943). (Bohem. & Morav. Protectorate). Fried Krupp A. G., *Production of Hard Metal Alloys.* A mixture of 2-48% TaC, 5-49% TiC, Mo_2C, VC or ZrC, and balance WC is pressed and sintered.

(3187) French 879,618 (1943). D. Seferian and V. Babayan, *Hard Carbide Alloy.* The base WC powder is mixed with Fe_3C, Cr_3C_2, or Mn_3C, and the mixture is pressed and sintered.

(3188) French 879,779 (1943). Harta A. G., *Hard Metal Alloy.* The alloy consists of 30-60% Fe_3C saturated with Mn_3C and B_4C, 10-20% WC and 15-25% Mo_2C.

(3189) German 733,318 (1943). Fried. Krupp, A. G., K. Schröter and W. Dawihl, *Method of Producing Hard Metal Alloys.* Powdered W and TiN is mixed with C and heated; the reaction product WC-TiC is crushed, mixed with an auxiliary metal, pressed and sintered.

(3190) German 736,810 (1943). Wallram Hartmetallwerk and Hartmetallwerkzeugfabrik Meutsch, Voigtländer & Co., *Metal Alloys.* An intermediate alloy is prepared consisting of one or more metals capable of forming hard carbides, *e.g.* W or Ta, and one or more metals incapable of forming carbides, *e.g.* Cu or Ag. To these is added V or Mn. The intermediate alloy is then carburized.

(3191) German 738,488 (1943). Deutsche Edelstahlwerke A. G. and P. Schwarzkopf, *Tool Alloy.* The alloy is composed of at least three carbides and an auxiliary metal. At least 50%, but preferably 80%, is made up of mixed crystals, and the rest of auxiliary metals.

(3192) German 739,427 (1943). Fried. Krupp A. G., W. Dawihl and K. Schröter, *Hard Metal Alloy for Tools.* The alloy consists of 30-50% Fe, 2-10% Cr, balance 1:2 or 1:0.5 TiC-WC and is formed into tools used to work materials, such as Cu, Al or steel with less than 60 kg./mm.^{2} strength.

(3193) German 740,350 (1943). Deutsche Edelstahlwerke A. G., R. Kieffer and H. Strauch, *Hard Metal Alloys for Tools.* The alloys consist of WC, 1.5-4.5% TiC, and 9-15% Fe, Ni or C.

(3194) German 741,840 (1943). Fried. Krupp A. G., *Sintered Hard Metal Alloys for Tools.* The composition consists of 1.5% WC with at least 3-7% C, 0.5-20% of an auxiliary metal and 30-98% VC, mixed in the powdered state.

(3195) German 742,042 (1943). Gebr. Böhler & Co. A. G., *Sintered Hard Metal Alloy.* An alloy for making tools consists of one of more carbides of Si, Ti, Zr, Ce, or Th as the main component, one or more of the metals Cr, W, Mo, at least part of which is in the form of carbides, and Fe, Co, Ni, or Mn as binder.

(3196) Swiss 226,722 (1943). Fried. Krupp A. G., *Hard Metal Alloy for Tools.* A mixture of Mo powder and C with 10% TiC is heated to 2000° C. (3630° F.) *in vacuo,* to form mixed crystals.

(3197) Swiss 228,705 (1943). Fried. Krupp A. G., *Hard Metal Alloy. Cf.* German 733,318 (No. 3189).

(3198) U. S. S. R. 63,674 (1943). M. G. Pekar, *Hard Alloys.* Ferro-chromium with 33% Cr is proposed as the auxiliary metal for making tools of WC-TiC.

(3199) U. S. S. R. 63,549 (1943). I. Unanski and G. N. Levin, *Mixed Carbides.* A mixture of WC, TiC and VC is sintered at temperatures sufficiently high to ensure the formation of a solid solution, but low enough to prevent N_2 from escaping into the furnace atmosphere, especially when using a carbon resistance furnace.

(3200) German 748,933 (1944). Deutsche Edelstahlwerke A. G. and R. Kieffer, *Hard Metal Alloy.* The alloy contains 60-80% TiC, 5-35% VC, balance 5-20% Fe, Ni and/or Co, preferably Fe; the VC content may be partly replaced by an equal proportion of a carbide of Cr, Zr, Mo and/or W. The alloy has good cutting and wear properties and is suitable for tools.

(3201) Swiss 231,521 (1944). Harta A. G., *Sintered Hard Metal Alloy.* An alloy used for tools to work steel, consists of 30-80% Fe_3C saturated with Mn_3C and B_4C and 70-20% of WC, TiC, TaC, Mo_2C, or CbC.

(3202) Swiss 232,168 (1944). E. Looser, *Sintered Carbides for Tools.* The materials are composed of (*1*) 59.5% TiC, 25.5% VC, 1.5% W, 1.8% Mo, 8.55% Co, 2.25% Cr and 0.9% Ta; or (2) 60.9% TiC, 17.4% WC, 8.7% Mo_2C, 8.71% Co, 1.95 Cr, 1.56% Mo and 0.78% Ta.

(3203) U. S. 2,349,052 (1944). J. O. Ollier, *Manufacture of Cemented Hard Metals for Tool Elements.* Carbide particles of B, Ti, Si, Ta, Cb, Cr, W, Mo are coated with about 2/3 of the lower-melting binder metal, and then the coated particles are mixed with the rest of the binder. The mixture is pressed and sintered below the melting point of the powdered binder component.

(3204) U. S. 2,356,009 (1944). P. Schwarzkopf (American Cutting Alloys Inc.), *Process for Manufacturing Hard Metal Compositions.* The process involves

preparing hard and refractory carbide crystal structures containing atoms of C in addition to atoms of W and Ti to form carbides by powdering and mixing them with powdered auxiliary metals (3-22% Ni and Co), shaping under pressure and sintering.

(3205) Brit. 570,875 (1945). E. A. Pokorny, *Hard Metal Containing Titanium Carbide.* A sintered composition of mixed TiC-WC contains WC plus 7-15% TiC and 3-14% Co. The carbides are produced by the reduction of the mixed oxides by C in the presence of a compound of B.

(3206) U. S. S. R. 65,067 (1945). G. A. Meerson, *Hard Alloys.* To an initial batch containing W and Ti to be formed into a complex carbide, is added the auxiliary cementing metal, Co or Ni, in a quantity less than ½ its content in the final alloy. The mixture is heated in a cartridge at 1700-2400° C. (3100-4350° F.) and the product is ground to a size not exceeding 5 μ. To this powder is added the remaining W and auxiliary metal, and the mixture is processed in the usual way.

(3207) Canadian 440,062 (1947). American Electro Metal Corp. and P. Schwarzkopf, *Hard Metal Composition.* Powdered WC or Mo_2C or both are mixed with powdered TiC, heated to 1500-2000° C. (2730-3630° F.), then comminuted and mixed with 5-20% metal of the Fe-group and 1-2% of a volatile binder.

(3208) Brit. 600,066 (1948). P. Schwarzkopf and J. O. Ollier, *Producing Hard Metal Composition.* The method of production comprises compacting W-Ti alloy powder, carburizing the compact and impregnating it with Co. The advantages claimed for the method are the elimination of a prolonged ball-milling, lower sintering temperature and shorter times.

(3209) Brit. Appl. 25537/48 (1948). Gebr. Böhler & Co. A. G., *Carbides of Titanium and Vanadium.* Both carbides are first prepared in an undercarburized form; TiC with 16.5-17.5% C; VC with 10-11% C. Fe or Ni are used as binder, and the mixture is sintered at 1550° C. (2820° F.).

(3210) Brit. Appl. 32319/48 (1948). Skoda Works, *Hard Metal Alloys.* Complex carbides are made such that Co is used with carbides of W, Ti, Zr, while 15-20% excess Ni is used with carbides of Mo, Ta, Cb.

(3211) Brit. Appl. 33063/48 (1948). Skoda Works, *Process for Producing Hard Metals.* Free C in WC base cutting tools is eliminated by adding ZrC which apparently can take up C in excess. The composition is 78% WC, 13% TiC, 3% ZrC, 6% Co. The theoretical C content is 8.55%, while 8.7-8.8% C is quite permissible.

(3212) Austrian 162,238 (1949). Metallwerk Plansee G.m.b.H., *Hard Metal Alloy.* The alloy consists of 55-80% TiC, 5-40% CbC, and 5-20% Fe, Ni or Co.

(3213) Brit. 613,356 (1949). Hard Metal Tools Ltd. and E. M. Trent, *Hard Alloys Resistant to Oxidation.* Double carbides of Ti and Cr, bonded with Ni, are presintered and shaped, then sintered in a furnace of fused alumina, not graphite; the resulting alloys are suitable for gas turbine blades.

(3214) Brit. 614,053 (1949). S. A. Le Carbone-Lorraine, *Manufacture of Alloys of Tungsten, Titanium and Carbon.* It is claimed that a solid solution of TiC and WC, when present in molecular ratio of 3-1, forms Ti_3WC_4 when heated to 2000° C. (3630° F.) and cooled slowly. The double carbide can also be prepared from mixed oxides and C.

(3215) Brit. 617,212 (1949). The British Thomson-Houston Co. Ltd., *Hard Metal Alloys.* Tools of exceptional toughness and wear resistance are obtained by preparing a 76/24 WTi carbide from the mixed oxides, ball-milling in acetone for 48 hours to 1-2μ together with 8% TaC and 22% Co, and ball-milling it with 110% coarse WC by weight of the complex carbide-Co mixture; the pressings are sintered.

(3216) Brit. Appl. 1,490/49 (1949). Skoda Works, *Hard Metal Alloys with Maximum Hardness.* Since the hardness of carbide mixtures varies with the temperature of their melting point, the following combinations are desirable for cutting tools: 2WC+Mo_2C; WC+TiC; 4TaC+ZrC; 4TiN+TiC.

(3217) Brit. Appl. 16,467/49 (1949). Metro-Cutanit Ltd., *Hard Metal Alloy of Complex Carbides.* In a complex carbide ZrC is added to increase the thermal conductivity, while the hardness is increased by the addition of up to 20% Cr_3C_2;

the combination of VC, CbC and Mo_2C is held to clean up oxide films, thus facilitating the sintering.

(3218) Swiss 263,716 (1949). Metallwerk Plansee G.m.b.H., *Hard Metal Alloy.* The alloy consists of 55-80% TiC, 5-40% CbC, and 5-20% Fe, Ni or Co.

iii. Other Compound-Base (Borides, Nitrides, Silicides, Oxides and Combinations thereof and with Carbides, and Non-Metal Carbides)

(3219) German 176,001 (1906). Gebr. Siemens & Co., *Production of Shaped Bodies of Silicon Carbide.* The process comprises mixing SiC with Si, pressing into shape, and sintering in N_2.

(3220) German 206,167 (1909). S. Tucker, *Boron Carbides.* The production of B_4C bodies entails mixing C with an excess of boric acid and heating under pressure in an electric furnace at 2500° C. (4700° F.).

(3221) German 257,468 (1913). Gebr. Siemens & Co., *Method of Producing Coils.* A method of producing coils comprises forming a body of SiCO, plus free C, obtained by heating Si and C in CO atmosphere, then heating the body to 1600-1700° C. (2910-3090° F.), whereby it is essentially transformed into SiC, and the free C is combined with the O, contained in the original SiCO body, to CO_2 which escapes.

(3222) German 295,547 (1916). E. Wedekind and Julius Pintsch A. G., *Tungsten Silicides and Borides.* The bodies are manufactured by mixing the components and pressing them into bars, and then resistance-sintering.

(3223) French 622,301 (1927). A. Brennecke, *Production of Hard Alloys.* W powder is mixed with C, B or Si, fused in molds and solidified.

(3224) U. S. 1,633,258 (1927). C. A. Laise, *Hard Metal Alloy.* W or Ta-oxides are reduced, mixed with B and/or C, pressed, and sintered at 700-1000° (1290-1830° F.) in a reducing atmosphere.

(3225) U. S. 1,652,027 (1927). H. Lohmann, *Hard Metallic Alloys For Cutting Tools.* Refractory metals W, Ti, Cr, Mo and Fe are fused with Si and B free of C and O, and the mixtures are subjected to centrifugal condensation.

(3226) Brit. 294,086 (1928). O. Diener, *Hard Alloy.* W and Co plus 0.1% B plus 1.5% Si are sintered under a pressure of 150-200 atm. (2100-2800 psi).

(3227) German 456,921 (1928). Hartstoff Metall A. G., *Bodies of Boron Carbide.* Bodies of B_4C are produced by melting the powdered material and adding C constantly to raise the C content above that of B_6C.

(3228) Belgian 562,618 (1929). Fried. Krupp, A. G., *Production of Hard Metals from Powders.* Metals are fused with C, B, Si, and, after a suitable structure is obtained, are pulverized, pressed and sintered.

(3229) Brit. 316,702 (1929). R. Walter, *Alloys.* The alloys contain one or more carbonitrides; an example is 2% Cr-carbonitride, 5% W-carbonitride, 8% Co, 5% W, and 80% WC.

(3230) Brit. 331,121 (1930). Fried. Krupp A. G. and G. Brewer, *Material of Great Hardness for Tools.* A mixture of Cr, Mo, Ti, W, U, V, and C, B or Si with or without Fe, Co, or Ni is powdered, pressed and sintered into suitable forms for tools.

(3231) German 504,484 (1930). O. Diener, *Hard Alloy Production.* Silicides, borides, carbides, Al_2O_3 or a mixture of these are sintered under pressure.

(3232) U. S. 1,774,849 (1930). K. Schröter (General Electric Co.), *Hard Alloys for Tools.* An alloy with a fine grained eutectic structure contains from 58-67% W, Mo or Cr and from 32-41% B, Ti, Si, or C.

(3233) Australian 961/1931 (1931). Fansteel Products Co. and C. W. Balke, *Hard Metal. Cf.:* Brit. 376,299 (No. 3244).

(3234) Australian 1328/1931 (1931). Fansteel Products Co. and C. W. Balke, *Sintered Hard Metal Alloy. Cf.:* Brit. 375,854 (No. 3243).

(3235) French 713,086; 713,087 (1931). Fansteel Products Co., *Borides and Carbides.* Powdered Ta, Cb, Mo or a mixture of these are heated together with finely powdered B or C until borides or carbides are formed.

(3236) French 715,148 (1931). Fried. Krupp A. G., *Hard Alloys Containing Titanium as Basic Material.* Alloys suitable for tools consist of a fritted mixture of the nitride and carbide of Ti. Up to 25% of an auxiliary metal may be present.

(3237) French 715,567 (1931). Fried. Krupp A. G., *Hard Metal Alloy.* Pure B is mixed with a metal of high melting point, pressed, and melted or sintered in reducing atmosphere or vacuum.

(3238) Swedish 79,452 (1931). Fried. Krupp A. G., C. Agte and K. Moers, *Sintered Hard Metal Alloy.* The alloy contains a sintered mixture of TiC and TiN

(3239) U. S. 1,811,068 (1931). R. Walter, *Wear Resistance Alloy for Cutting Tools.* The alloy is produced by compressing and sintering a powder mixture containing over 50% carbonitride of Cr and up to 30% of a high melting metal of the Cr-group, with the remainder consisting of a metal of the Fe-group.

(3240) U. S. 1,820,966 (1931). I. G. Donaldson and H. L. Coles (Guardian Metals Co.), *Refractory Alloy for Safe Construction.* The alloy is a complex refractory metal silicocarbide, analyzing 90% W, 1% Mo, 4% C, 3% Si, and 2% Ni binder.

(3241) Austrian 130,627 (1932). Fried. Krupp A. G., *Hard Metal Alloys.* The alloys consist of B plus Ti, Zr, V, W, Mn, Co or Fe, and are heated in vacuum.

(3242) Brit. 365,895 (1932). Fried. Krupp A. G., *Hard Alloy for Tools. Cf.:* German 582,323 (No. 3262).

(3243) Brit. 375,854 (1932). Fansteel Products Co. and C. W. Balke, *Sintered Hard Metal Alloy.* A sintered alloy consists of borides and/or carbides of Ta, Mo, Cb or W and an Fe-group metal.

(3244) Brit. 376,299 (1932). Fansteel Products Co. and C. W. Balke, *Hard Metal.* The production of a hard metal comprises sintering *in vacuo* a powdered mixture of high-melting point metals, especially Ta and B and/or C and an Fe-group metal.

(3245) Brit. 376,836 (1932). Fried. Krupp A. G., *Hard Metal Alloys. Cf.:* Austrian 130,627 (No. 3241).

(3246) Brit. 378,484 (1932). Fried. Krupp A. G., *Carbide-Containing Alloys.* A sintered hard alloy for tools contains 75% or more of B_4C and Si-, V-, W-, Mo-, Hf-, or Zr-carbides plus Fe, Ni, Co or Cr.

(3247) Brit. 379,681 (1932). Fansteel Products Co., *Sintered Tool Alloys From Refractory Metal Borides.* Ta-, Cb- or V-boride, obtained by grinding, plus Fe, Co, Ni are heated in an evacuated electric furnace in a Ta crucible, or Ta powder inside a graphite crucible.

(3248) French 728,468 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Alloy.* The alloy consists of TiC and other compounds and an Fe-group metal; an example is 7% TiC, 3% TiN, 85% WC and 5% Co.

(3249) French 741,646 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Sintered Alloys for Tools.* The alloys contain at least 50% silicides or borides, together with carbides, of W, Mo, Ta, Ti, and up to 25% of Co, Ni, Fe, Mn.

(3250) Japan. 94,997 (1932). T. Kase and K. Honda, *Hard Alloy.* An alloy of 10-50% B, 0.5-60% Ni, 30-80% Fe, 0.5-2% C, 1.5-5% Mn and 1-15% Cu is used as a hard substitute for topaz.

(3251) Swiss 158,002 (1932). Fansteel Products Co., *Sintered Hard Metal Alloy Cf.:* Brit. 375,854 (No. 3243).

(3252) U. S. 1,842,103 (1932). C. A. Laise (Eisler Electric Corp.), *Refractory Material.* WC, containing up to 5% Be_2C plus Be_3N_2, is impregnated with a metal of the Fe-group in a proportion up to 35%.

(3253) Austrian 133,124 (1933). Fried. Krupp A. G., *Hard Alloys. Cf:* German 588,911 (No. 3263).

(3254) Austrian 135,324 (1933). H. Fasching, *Refractory Metal Carbides and Nitrides.* A powdered mixture of refractory metal carbides or nitrides with a higher melting metal is heated in a mold under pressure to a temperature just above the melting point of the compound, and then cooled under pressure.

(3255) Austrian 135,522 (1933). Fried. Krupp A. G., *Homogeneous Alloy of Great Hardness for Tools.* The manufacture involves melting a refractory metal mixed with B, Si or C, cooling it rapidly, pulverizing and sintering at a temperature low enough so as not to disturb the fine grain structure.

(3256) Brit. 392,038 (1933). Tool Metal Manufacturing Co., Ltd., *Hard Sintered Alloys.* The alloys consist of 50% or more of one or more borides, silicides, or silico-borides of W, Mo, Ti, Zr, Th, V, Cb, Ta, and Al, of more than 0.5% of at least one carbide of W, Mo, Ta, Ti, and up to 25% Fe, Ni, Mn, Co.

(3257) Brit. 398,661 (1933). Tool Metal Manufacturing Co., Ltd., *Sintered Refractory Alloys.* The alloys consist of a refractory metal nitride and boride or silicide, totaling 55%, plus 20% of a refractory carbide, balance Ni, Co, or Cr.

(3258) Brit. 402,742 (1933). Fried. Krupp A. G., *Hardening Alloys for Cutting Tools.* Alloys for cutting tools are produced by incorporating hard metal nitrides or carbides in a starting material such as Fe-Ti or Fe-Ta powder, and subjecting the mixture to a precipitation hardening.

(3259) French 744,361 (1933). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Metal Alloys.* Alloys contain a refractory metal nitride as well as a boride and/or silicide, *e.g.* 34% TiN, 60% TiB_2 and 6% Ni.

(3260) French 756,992 (1933). G. Boecker, *Sintered Hard Alloys for Tools.* The alloys contain (*1*) 40-80% Ti, 10-50% Si and 1-15% Co; or (2) 15-50% Ti, 40-80% B and 1-15% Co. Al, Mg, Be and V may be used up to 15% and 2% Fe may be added.

(3261) French 757,419 (1933). Wolfram & Molybdän A. G., *Boron-Containing Sintered Carbides. Cf:* Swiss 163,608 (No. 3270).

(3262) German 582,323 (1933). Fried. Krupp A. G., C. Agte and K. Moers, *Hard Alloys for Tools.* The alloys consist of TiN and TiC, sintered together in equal quantities; up to 25% Co, Fe or Ni is added as binder.

(3263) German 588,911 (1933). Fried. Krupp A. G., H. Wolff, K. Schröter and K. Moers, *Hard Alloys.* A sintered hard alloy consists of 15% B_4C and one or more carbides of refractory metals with a melting point above 2000° C. (3630° F.), which serve to reduce the porosity, and a metal of lower melting point as binder.

(3264) Swiss 161,100 (1933). Fried. Krupp A. G., *Hard Metal Alloys. Cf.:* Austrian 136,372 (No. 3274).

(3265) Swiss 161,897 (1933). Fried. Krupp A. G., *Hard Metal Alloy.* The alloy contains more than 50% B and a metal with melting point above 1000° C. (1830° F.).

(3266) Swiss 162,515 (1933). Fansteel Products Co., *Hard Metal. Cf.* Brit. 376,299 (No. 3244).

(3267) Swiss 162,517; 162,518; 162,519; 162,520 (1933). Wolfram & Molybdän A. G., *Hard Metal Alloys for Tools.* The alloys contain TiC or TiN and TaC or TaN plus Ni-W, Co-W, Fe-W, Fe-Co-W, Cr-Co-W or Cr-Co.

(3268) Swiss 163,063 (1933). Fried. Krupp A. G., *Hard Metal Alloy.* The alloy consists of silicides plus carbides of high melting metals and up to 25% of a binder metal.

(3269) Swiss 163,064 (1933). Fried. Krupp A. G., *Hard Metal Alloy.* Alloy consists of borides and carbides of high melting metals and up to 25% of a binder metal.

(3270) Swiss 163,608 (1933). Wolfram & Molybdän A. G., *Boron-Containing Sintered Carbides.* The alloy contains 75% of WC, TaC, TiC, CbC, VC, ZrC, HfC or Mo_2C plus 8-25% of FeB or FeNiB; the alloy is produced by milling, pressing and sintering slightly above the melting point of the boron-containing pre-alloy.

(3271) Swiss 164,596 (1933). Fried. Krupp A. G., *Sintered Hard Metal Alloy.* The alloy consists of less than 50% of a high melting metal nitride and high melting metal boride mixed with an auxiliary metal as binder.

(3272) U. S. 1,895,959 (1933). C. Agte and K. Moers (Fried. Krupp A. G.), *Hard Products Containing Titanium Carbide and Nitride.* A hard material suitable for tools comprises 99-75% of a fused mixture of TiC and TiN and 1-25% of an Fe-group metal like Co.

(3273) U. S. 1,913,373 (1933). De Golyer, A. G., *Hard Material for Cutting Tools and Dies.* Hard crystals and particles of metal borides of W and Cr are cemented by a binder containing Cu and Be in a proportion smaller than that of the boride.

(3274) Austrian 136,372 (1934). Fried. Krupp A. G., *Hard Metal Alloys.* The alloys contain 25% Fe, Co, Ni, Mn and 50% of silicides or borides or both, plus an addition of W-, Mo-, Ta-, or Ti-carbides, singly or mixed.

(3275) Austrian 139,093 (1934). Fagersta Bruks A. B., *Hard Metal Alloy for Tools. Cf:* U. S. 1,996,220 (No. 3296).

(3276) Brit. 405,119 (1934). Wolfram & Molybdän A. G., *Hard Alloy for Tools.* The alloy consists of 50% WC, 30% Fe, Co or Ni, and hard mixed crystals of carbides or nitrides such as TiC-TaC or TiN-TaC or TaN-TiC.

(3277) Brit. 408,716 (1934). Fagersta Bruks A. B., *Hard Metal Alloy for Tools. Cf:* U. S. 1,996,220 (No. 3296).

(3278) Brit. 412,099 (1934). Wolfram & Molybdän Co., *Sintered Hard Alloys Containing Borides.* The alloys comprise W_2C as main constituent and up to 25% of a boride of Fe, Ni, or Co, as auxiliary metal.

(3279) Brit. 416,408 (1934). J. H. L. De Bats, *Method of Making Cemented Hard Metals for Tools.* W, Ta or Mo-compounds, such as borides, silicides, carbides or tellurides, and Fe, Ni and Co are mixed in powdered form, sintered to near the melting point, then pressed and centrifugally cast.

(3280) Canadian 342,124 (1934). Fried. Krupp A. G., *Sintered Alloy.* The alloy consists of TiC, TiN, TiB and WC; an auxiliary metal is added.

(3281) Canadian 346,719 (1934). C. W. Balke, Fansteel Products Co. and Ramet Corp. of America, *Refractory Metal Borides.* Ta, Cb, Mo or W powders are mixed with purified B, in the amorphous state or as a chemical compound. The mixtures are pressed and sintered in vacuum.

(3282) French 762,072 (1934). Societé Aubert et Duval Freres, *Refractory Alloys from Hard Metals and Metalloids.* Refractory alloys from metals such as W, Ta, Mo and Ti, and metalloids such as Si and B, with or without an auxiliary metal, such as Fe, Co, or Ni, are produced by compression of the powdered ingredients at 20-30,000 atm. (145-220 tsi).

(3283) French 778,137 (1934). Siemens & Halske A. G., *Hard Refractory Metal Compositions.* Powdered carbides, borides and/or nitrides of W, Mo, Ta, or Ti, with or without a metal of the Fe-group, are made plastic by a solution of an electrolyte, molded and sintered.

(3284) German 605,108 (1934). R. Walter, *Production of Sintered Hard Alloys.* The starting material is a double carbide of Cr and W, *e.g.* $3Cr_3C_2 \cdot W_2C$, which is mixed with carbides and/or nitrides of other metals.

(3285) Swiss 171,084 (1934). G. Boecker, *Hard Metal Bodies.* An alloy of 40-80% Ti, 10-50% Si and 15% Co is mixed with 10% Al, Mg or Be and moistened, pressed in forms and sintered.

(3286) U. S. 1,968,067 (1934). C. W. Balke (Ramet Corp. of America), *Alloy and Method of Making Same.* The hard alloy contains TaB_2 plus 3-15% binder of the Fe-group.

(3287) Austrian 140,549 (1935). Fansteel Products Co., *Sintered Hard Metal Alloy. Cf:* Brit. 375,854 (No. 3243).

(3288) Austrian 142,076 (1935). G. Boecker, *Hard Metal Alloys.* The alloys consist of Ti and 20% Co and 50% B, or up to 30% Si and up to 50% Mg, Al, V or Be; the Ti may be partly or fully replaced by W. The alloys are mechanically worked and sintered.

(3289) Brit. 426,600 (1935). Siemens & Halske A. G., *Production of Sintered Bodies. Cf:* German 627,980 (No. 3306).

(3290) Brit. 436,017 (1935). General Electric Co. Ltd. and J. H. Partridge, *Cutting or Dividing Glass.* A mixture of finely divided Al_2O_3 with 10% Fe_2O_3 is pressed into a bar with sharp edges; the bar is sintered at 1700° C. (3090° F.) in a Mo-wound electric furnace in H_2. The resulting material is more wear-resistant than carborundum.

(3291) Brit. 439,379 (1935). British Thomson-Houston Co. Ltd., *Cemented Hard Materials for Cutting Tools.* The alloys comprise carbides and nitrides or carbonitrides of Ti, carbides of W, and a binding alloy of W, Co or Mo, Cr, V, Fe.

(3292) Brit. 439,975 (1935). E. Schjöth, *Hard Metal Alloys.* The alloys are produced by forming a colloidal suspension of a carbide, a silicide, boride or nitride, and another such suspension of an auxiliary metal, mixing the emulsions, drying, pressing and sintering.

(3293) French 779,879 (1935). G. Boecker, *Method of Producing Hard Alloys.* A mixture of oxides of Ti, B, and Co, plus Al for purposes of reduction, is heated in a mold by thermite heating and then cooled very quickly while pressing the contents of the mold under great pressure.

(3294) French 790,767 (1935). Rheinische Metallwaren & Maschinenfabrik and G. Boecker, *Sintered Hard Metals. Cf:* Swiss 183,738 (No. 3311).

(3295) German 608,664 (1935). Fried. Krupp A. G., K. Schröter and K. Moers, *High Boron Refractory Alloys.* Powdered B (85%) may be alloyed with 15% of Zr; the powders are mixed and pressed, then sintered at temperatures from 1350 to 2100° C. (2460° to 3800° F.).

(3296) U. S. 1,996,220 (1935). K. M. Tigerschiöld and G. Sterky (Fagersta Bruks A. B.), *Hard Metal Alloy for Tools.* Carbides and nitrides of high-melting metals, mixed with auxiliary metals, are pre-pressed and exposed to the action of chemicals such as chlorides or sulfates, which attack the surface of the lower melting metal; the product is then worked mechanically, annealed, pressed and finally sintered.

(3297) U. S. 2,015,536 (1935). K. Moers, H. Wolff, C. Agte and K. Schröter (General Electric Co.), *Sintered Hard Metal Compositions Containing Tungsten Carbide.* The alloys consist of 60-80% WC, 10-30% of a Ti-compound from the group of TiC, TiN, TiB_2 and 25% Fe.

(3298) U. S. 2,018,752 (1935). R. Walter, *Sintered Alloys of Tungsten Carbide and Carbonitride with Tungsten and Cobalt.* Alloys suitable for machining tools etc. are formed from W-carbide and/or -carbonitride (50-80%) and a metal such as W or Co.

(3299) U. S. 2,021,021 (1935). A. R. Powell and E. R. Box (Johnson, Matthey & Co. Ltd.), *Hard Metal Alloy.* A mixture of 50-75% W, 2-40% Pt, 0.5-5% B and 5-25% Ni or Co is pressed and sintered.

(3300) Austrian 144,356 (1936). Siemens & Halske A. G., *Production of Sintered Bodies. Cf:* German 627,980 (No. 3306).

(3301) Brit. 444,995 (1936). Rheinische Metallwaren & Maschinenfabrik and G. Boecker, *Sintered Hard Metals. Cf:* Swiss 183,738 (No. 3311).

(3302) Danish 52,066 (1936). Fagersta Bruks A. B., *Sintered Hard Metal Bodies.* A lower melting metal is added to carbides or borides of W, Ti, Ta in form of a compound, reducible by gas, such as oxide or carbonate; the compound compacts of the starting material are pressed, reduced and finally sintered.

(3303) French 800,730 (1936). A. Kratky, *Nitrides and Carbides of Metals.* A combination of powdered refractory metals and C or N is pressed; the bars are heated at 1900° C. (3450° F.), for a short time in vacuum or protective atmosphere.

(3304) French 802,603 (1936). P. Scholtes, *Hard Metal Bodies.* The bodies consist of borides and silicides of W plus Ti, Ta and Co (3%) as binder.

(3305) German 626,316 (1936). A. Karst, *Amalgamated Hard Alloy Articles.* Particles of a carbide, borocarbide or nitride of W, Mo, Ti or Ta are amalgamated with a metal of a lower melting point. Amalgamation is effected by suspension or deposition of the low melting metal powder. The particles are pressed and sintered.

(3306) German 627,980 (1936). Siemens & Halske A. G., *Production of Sintered Bodies.* Hollow bodies are formed of metals, such as W, Mo, Ti or Ta, or carbides, borides or nitrides by addition of a powder of an electrolyte in a quantity sufficient to produce fluidity in the cold state; the mass is poured into an absorbent mold, dried and sintered. As example, 80% WC, 10% TiC, 10% Co are mixed by adding a solution of Co-nitrate in water and glycerin.

(3307) Swedish 87,298 (1936). Fagersta Bruks A. B., K. M. Tigerschiöld, and K. Bonthron, *Sintered Cemented Refractory Metals.* W, Mo, or Ta-compounds, *e.g.*, silicides, nitrides, borides, or carbides are mixed with W or Mo metal powder and Fe, Ni or Co-oxide powder; the pressed bodies are sintered in a reducing atmosphere.

(3308) Swedish 87,501 (1936). Vereinigte Edelstahl A. G., *Production of Sintered Bodies from Refractory Metals or Alloys. Cf:* German 627,980 (No. 3306).

(3309) Swiss 181,866 (1936). V. Sauter, *Hard Metal Bodies.* V, Cb, or Ta, containing B, are mixed with up to 10% Ir, pressed and sintered by induction.

(3310) Swiss 181,868 (1936). V. Sauter, *Hard Metal Body.* A hard metal body of great tenacity is produced by mixing carbides and borides of the 5-6th group of the periodic system, *e.g.*, V, Cb, W, or Mo, with 8% Ag, followed by forming and sintering in an induction field of 10,000-15,000 voltage.

(3311) Swiss 183,738 (1936). Rheinische Metallwaren & Maschinenfabrik and G. Boecker, *Sintered Hard Metals.* A sintered mixture of WC, plus other carbides, silicides, borides and auxiliary metal is prepared by precipitating the auxiliary metal electro-galvanically on a cathode mass of pressed hard metal powder.

(3312) U. S. 2,036,245 (1936). R. Walter, *Carbide-Containing Alloys Suitable for Cutting Tools.* About 10-49% of a cementation metal such as Co and W is used with about 50-90% carbide and a smaller proportion of an azotized carbide (carbonitride) of W and Cr or Mo.

(3313) U. S. 2,059,041 (1936). K. Moers and K. Schröter (General Electric Co.), *Sintered Boron Alloys.* The alloys are composed of 85% B with 15% of a brittleness-reducing metal, *e.g.* Zr, Ti, V, Cr, W, Mn, Co or Fe; the powders are pressed and sintered in vacuum at 2100° C. (3810° F.), or hot pressed in A, H_2 or vacuum; preheating in vacuum to degas is also claimed.

(3314) French 814,171 (1937). P. Marth, *Hard Alloys from Powders.* Alloys of great tenacity and hardness are obtained by heating powdered refractory metal compounds, such as carbides, nitrides, silicides, borides and W-Cr-Co powder to the fusion point under H_2 in an oxyacetylene flame.

(3315) French 814,186 (1937). P. Marth, *Hard Alloys from Powders.* Hard alloys are obtained by a partial liquefication process of carbides, nitrides, silicides, or borides of metals and powdered auxiliary metals.

(3316) French 47,685 Addn. (1937). Soc. Industrielle et Commerciale Des Aciers, *Hard Alloys.* Addition to French 808,096 (No. 3084). The alloy consists of 10% TiC, 4% TiN, 1.5% VN, 5.5% Co, remainder WC.

(3317) German 650,001 (1937). Fried. Krupp A. G., and C. Agte, K. Moers, K. Schröter, and H. Wolff, *Sintered Hard Alloys.* Supplement to German 622,347 (No. 3043). Modified in that the TiC is replaced by a nitride, boride or silicide of Ti.

(3318) Swedish 88,681 (1937). Fagersta Bruks A. B. and K. J. A. Bonthron, *Sintered Cemented Refractory Metals.* Addition to Swedish 87,298 (No. 3307). In a modification, the alloys contain 5-25% TiC and up to 30% reducible compounds for the binder.

(3319) U. S. 2,073,826 (1937). C. W. Balke (Ramet Corp. of America), *Manufacture of Borides.* A metal of the refractory metal group and pure B are ground together and heated *in vacuo.*

(3320) U. S. 2,074,847 (1937). L. E. Lemaigre (General Electric Co.), *Sintered Hard Cutting Tool Composition.* A composition suitable for rapid machining of steels is formed of WC, TiC, TiN and a binder alloy containing Co and W.

(3321) U. S. 2,077,239 (1937). J. Hinnüber (General Electric Co.), *Sintered Hard Refractory Nitrides.* The compositions contain 55% or more of VN or TiN together with Ti- or Ta-boride or silicide plus 1-25% Ni or Co.

(3322) U. S. 2,084,349 (1937). C. A. Laise, *Wear-Resistant Material from Refractory Metals.* Powdered W plus Fe, Co, Ni, Cr are mixed together in the proper proportion and presintered. The alloyed material is powdered, carburized and boronized to give a total of 13% C and B, compacted and finally sintered.

(3323) U. S. 2,088,981 (1937). W. B. Sturgis, *Super-Hard Tool Material.* A base of super-hard compound such as Ti-nitride, boride or silicide and a Ta-metal matrix or cementing material is mixed with a flux, such as Co-oxide, in a ball-mill, then moistened, pressed and sintered.

(3324) U. S. 2,097,176 (1937). A. G. De Golyer, *Alloy Containing Boron, Tungsten and Cobalt.* An age hardenable alloy contains 0.5-2.75% B, 5-25% W or Mo, balance Co.

(3325) Brit. 478,016 (1938). P. Marth, *Production of Very Hard Substances.* The process consists of directly heating carbides, nitrides, silicides or borides of refractory metals to 3400° C. (6180° F.) in the presence of atomic H.

(3326) Brit. 478,025 (1938). P. Marth, *Hard Alloys.* Nitrides, borides, or silicides of W, Ti, Ta, Mo, V, Zr, Ca, Si, Al, Be or Cr are sintered in H_2 atmosphere.

(3327) Brit. 478,026 (1938). P. Marth, *Compositions Containing Metals and Abrasives.* Hard substances, *e.g.* carbides, nitrides, silicides or borides, as described in Brit. 478,016 (No. 3325) are powdered and mixed with metal powders of the Fe-group or their alloys with W, Cr, Mn, Mo or V, pressed and heated to sintering temperature in a refractory mold.

(3328) Brit. 478,534 (1938). Fried. Krupp A. G., *Sintered Hard Alloys.* Addition to Brit. 465,323 (No. 3080). In a modification, the VC is wholly or partly replaced by VB_2 and/or VN and the TiC is replaced by TiN.

(3329) German 659,917 (1938). Fried. Krupp A. G. and J. Hinnüber, *Hard Alloy.* A hard alloy consists of: (*1*) 34% TiN, 60% TiB_2, 6% Ni, or (*2*) 12% VN, 78% TaB_2, 10% Ni.

(3330) German 664,644 (1938). Norton Co., *Silicon or Boron Carbide Materials.* SiC or B_4C for grinding purposes are produced by heating a core of carbides mixed with powder of a conductive metal with a secondary resistor, to give a carbide block without impurities.

(3331) German 667,071 (1938). Fried. Krupp A. G. and J. Hinnüber, *Hard Alloys.* A sintered hard alloy consists of 1-49% of a carbide of W, Mo, Ta, Ti, single or mixed, 1-25% Fe, Ni, Co and the remainder a boride or silicide of W, Ta, Ti or Cr.

(3332) U. S. 2,108,618 (1938). K. S. Seljesaeter (Western Electric Co.), *Sintered Hard Alloys Suitable for Tools.* The alloys contain 1-15% Co, Fe or Ni and 85-99% of a mixture of TaN and TaC.

(3333) U. S. 2,116,399; 2,116,400 (1938). P. Marth, *Shaped Bodies of Extremely Hard Materials.* Carbides, nitrides, silicides, borides and easily fusible auxiliary metals plus B, and W-Cr-Co alloys are heated in H_2 above the melting point of the binders.

(3334) U. S. 2,123,046 (1938). J. Hinnüber (General Electric Co.), *Sintered Hard Alloy.* The alloy consists of 1% VC, 0.5% VN, 15% TiC, 5.5% Co, and balance WC. Nitrides and borides of W, Mo, Ti, Ta, Zr, or V may also be added.

(3335) U. S. S. R. 56,039 (1938). W. I. Woloschin, *Sintering of Metals of Iron Group.* Fe, Ni or Co are mixed with sintered SiC and sintered at 1700-2000° C. (3090-3630° F.).

(3336) Brit. 503,397 (1939). H. Petersson, *Hard Alloys.* Hard metal alloys consist of 20/50% TiC, 10-30% Mo_2C, 5-20% TaC, 10-30% W, 0.1-1% Co, 0.5-5% B and 0.5-5% Si.

(3337) Brit. 504,522 (1939). H. Petersson, *Hard Metal Alloy.* The alloy consists of a mixture of 74% WC, 22% W, 0.5% Co, 2% B, 1.5% Si.

(3338) Brit. 504,543 (1939). F. Eisner, *Production of Hard Alloys.* Finely crystalline and very hard bodies of WC and/or Mo_2C are produced by adding a substance consisting of a hard metal carbide, boride or nitride having a melting point higher than that of the initial material, which forms crystallization nuclei.

(3339) Canadian 380,522 (1939). Canadian General Electric Co., Ltd., *Sintered Hard Alloy.* The alloy consists of 2% VC, 1.5% VB_2, 2% TiC, 15% TiN, 5% Co, remainder WC.

(3340) French 838,631 (1939). H. Petersson, *Hard Alloys. Cf:* Brit. 503,397 (No. 3336).

(3341) French 839,567 (Addn. 50,281) (1939). Fried. Krupp A. G., *Hard Alloys.* A hard alloy for tools consists of a mixture of Al_2O_3 with 20-40% Fe_2O_3, sintered at a temperature above the melting point of the lower melting oxide.

(3342) Austrian 159,790 (1940). Fried. Krupp, A. G., *Sintered Hard Alloy.* The production involves the addition of at least 1% of a nitride and 1% of a boride of one of the metals W, Mo, Ta, Ti, Va, Zr, to the refractory metal carbide.

(3343) German 687,397; 687,398 (1940). Fried. Krupp A. G., *Cutting Tools.* Sintered Al_2O_3 cutting tools contain 20-40% Fe as an auxiliary metal.

(3344) U. S. 2,224,595 (1940). W. Dawihl and K. Schröter (General Electric Co.), *Method for Producing Oxide-Base Cutting Tools.* A method of lowering the sintering temperature of cutting tools consists of using finely divided Al_2O_3 and 20-40% of a softer ductile metal, and adding 10% oxides capable of lowering the sintering temperature.

(3345) U. S. 2,200,258 (1940). J. A. Boyer (The Carborundum Co.), *Boron Carbide Composition.* A wear-resistant article is prepared by crushing an alloy of Cu and B_4C containing 50% Cu and rebonding the crushed alloy by sintering in desired shape.

(3346) U. S. S. R. 57,826 (1940). M. Yu. Bal'shin, *Hard Alloys.* Brittleness is prevented in sintered hard alloys by adding Fe or Ni together with 20% (based on Fe or Ni) of Si or Al.

(3347) Austrian 160,359 (1941). Rheinmetall-Borsig A. G., *Production of Hard Metal Bodies.* Several refractory metal powders are mixed with graphite, B or Si, but without addition of an auxiliary metal, formed and sintered at a temperature at which the structural change to carbides, borides or silicides is completed.

(3348) Czech. 70,261 (1941). (Bohem. & Morav. Protectorate). Poldihütte, *Sintered Hard Metal Alloy.* The alloy contains 3-30% of mixed crystals of nitrides and carbides of metals of the 4th or 5th group of the periodic system; *e.g.*, TiN-TiC, TiN-TaC, TaN-TaC, TaN-TiC.

(3349) German 709,952 (1941). Heraeus Vacuumschmelze A. G. and W. Rohn, *Production of Tools of Hard Metal Powders.* A sintered alloy contains a mixture of carbides, silicides or titanides and a heavy metal alloy (containing Ti), with tempering quality and a melting point above 1000° C. (1830° F.) as an auxiliary metal; the finished tool is quenched and annealed at 500-700° C. (930-1290° F.) for tempering.

(3350) German 710,123 (1941). Meutsch, Voigtländer & Co., *Hard Alloy for Cutting Tools.* The alloy consists of carbides, borides, and/or silicides of W, Mo, Ta, Ti, Cr, or V, soft auxiliary components such as Cu or Ag, and components for hardening the auxiliary metals, such as Si or Ti.

(3351) U. S. 2,251,007 (1941). K. Schröter and W. Dawihl (General Electric Co.), *Oxide-Base Hard Material.* One or more oxides are secured to a shank by glass solder, and used as cutting tips for a machining tool.

(3352) German 720,357 (1942). Rheinmetall-Borsig A. G., G. Boecker and W. Kniprath, *Method of Producing Hard Metal Bodies.* W, V, or Ti powders are mixed with C, Si, and B in such quantities that after forming and sintering the products contain carbides, silicides and borides, which cause a tight coherence of the particles. No lower melting metals are added.

(3353) Italian 395,588 (1942). M. Cucumo, *High-Hardness Alloy Bodies for Piercing, Cutting and Resistance Elements.* A very hard alloy is composed of a mixture of synthetic corundum (Al_2O_3) and stable hard carbides of metalloids or of metals, or of both, singly or in combination, bonded by tough metals having a melting point lower than that of synthetic corundum; sintering is carried out at a temperature higher than the maximum melting temperature of the tough metals added, but not higher than the melting point of the synthetic corundum.

(3354) Italian 395,732 (1942). M. Cucumo, *High Hardness Alloy for Piercing, Cutting and Resistance Elements.* A very hard alloy is composed of very hard substances in the form of carbides, borides, nitrides, silicides, oxides and the like, bonded with a material whose components impart to the material itself the characteristics of a super-high-speed steel, that is to say, toughness and hardness even at elevated temperatures.

(3355) Swedish 107,302 (1943). Fagersta Bruks A. B., *Process for Making Objects or Compacts of Sintered Hard Metals and Products Obtained by this Process.* Oxides of one or several of the high melting metals such as Ti, Zr, V, Ta, Cb, Cr, W or Mo are mixed with one or several of the metalloids, *e.g.* C, B, Si, or N_2, and possibly with the oxide of a suitable auxiliary metal having a lower melting point, *e.g.*,Co, Fe, or Ni, in a ball mill together with a liquid such as water which may contain a wetting agent such as ammonia. The mass is then dried, pressed and sintered.

(3356) Brit. Appl. 13283/47 (1947). American Electro Metal Corp., *Hard Metal Composition.* Cr-boride for tools is bonded with a preformed alloy of 65-75% Ni, 13-20% Cr, 2.75-4.75% B and with 10% Fe-Si-Co.

(3357) Brit. Appl. 13452/47 (1947). American Electro Metal Corp., *Hard Metal Composition.* The Cr-boride material for tools covered by Brit. Appl. 13283/47 (No. 3356) is produced as a porous compact and impregnated with a liquid binder.

(3358) Brit. Appl. 18541/47 (1947). American Electro Metal Corp., *Structural Material for Shaped Bodies.* Cr-boride-base material is bonded with Ni-base or Co-base binder for high-temperature service parts (*e.g.* turbine blades, or nozzles for jet propulsion). W, Mo, Ta is incorporated in Cr-boride to give a mixed boride-base.

(3359) Austrian 162,054; 162,646 (1949). Metallwerk Plansee G.m.b.H., *Material of Great Hardness.* The material consists of 50-97% B_4C, Al_2O_3, SiO_2, B_2O_3, and ZrO_2, or TiO_2, and can be used as tool material, for grinding tools, or for wear resistant products.

(3360) Austrian 162,399 (1949). Metallwerk Plansee G.m.b.H., *Hard Metal Alloy for Grinding Purpose.* The alloy contains more than 50% B_4C, remainder other metal carbides, embedded in hard metal or artificial resin.

(3361) Austrian 164,564 (1949). Metallwerk Plansee G.m.b.H., *Material for Grinding Tools.* The material consists of 30-80% B_4C, remainder Ti or Ta, embedded in a matrix of hard metal, ceramic or artificial resin.

(3362) Brit. 626,445 (1949). A. L. Roberts and E. T. Paris, *Ceramic Cutting Tools.* Al_2O_3 tips are obtained by including a small amount of Al, Cr or Mg powders in pure calcined Al_2O_3 powder. The formation of fresh oxides from these powders has an effect upon the growth of Al_2O_3 crystallites during the subsequent firing.

B. Hard Metal Products

(3363) German 284,808 (1915). Allgemeine Elektrizitäts Gesellschaft, *Drawing Tool.* A drawing tool is manufactured from a formed mixture of Al_2O_3 and a volatile binding agent; production involves sintering at 1300° C. (2370° F.), then coining and again sintering at 2000° C. (3630° F.).

(3364) U. S. 1,551,333 (1925). K. Schröter (General Electric Co.), *Tools From Metals that Fuse at Approximately 1000° C.* Hard alloy tools or implements have as a base one of the elements of the 4-6th group of the periodic system, which are fusible over 1000° C. (1830° F.) and are provided with a surface consisting of layers of different proportions of mixtures of this metal and a metalloid, produced by carbonizing or boronizing.

(3365) Swedish 65,409 (1926). Fried. Krupp A. G., *Method for the Production of Tools from Sintered Hard Metal Alloys. Cf:* German 481,212 (No. 3371).

(3366) Brit. 262,723 (1927). Fried. Krupp A. G., *Method for the Production of Tools from Sintered Hard Metal Alloys. Cf:* German 481,212 (No. 3371).

(3367) Czech. 24,715 (1927). Fried. Krupp A. G. and K. Schröter, *Method for the Production of Tools from Sintered Hard Metal Alloys. Cf:* German 481,212 (No. 3371).

(3368) German 443,911 (1927). Patent Treuhand-Gesellschaft für elektrische Glühlampen, *Production of Drawing Dies.* Porous drawing die bodies of WC or Mo_2C are impregnated with molten Fe.

(3369) Swiss 120,304 (1927). Fried. Krupp A. G., *Method for the Production of Tools from Sintered Hard Metal Alloys. Cf:* German 481,212 (No. 3371).

(3370) Dutch 34,148 (1929). Allgemeine Elektrizitäts Gesellschaft, *Needles for Record Players.* The needles consist of 65-95% W or Mo, 3-10% C and 3-25% Co.

(3371) German 481,212 (1929). Fried. Krupp A. G. and K. Schröter, *Method for the Production of Tools from Sintered Hard Metal Alloys.* Solid tool tips and the like bodies are produced by application of pressure to a mixture of WC and/or Mo_2C with Co, Ni or Fe; the pressings are subjected to sintering at 900° C. (1650° F.), then brought into shape and sintered at a higher temperature.

(3372) U. S. 1,728,909 (1929). K. Schröter (General Electric Co.), *Tools of Sintered Hard Metals.* WC and Fe, Co, Ni are pressed, presintered at 700-1100° C. (1300-2000° F.), formed into shape, and sintered at a higher temperature, for the manufacture of tool tips and the like.

(3373) U. S. 1,740,009 (1929). O. Diener, *Manufacture of Tools of Tungsten.* Tools are produced from W with more than 3% C by heating up to 2000° (3630° F.) and simultaneously forming under high reaction pressure up to 150-200 kg./cm.^{2} (2000-3000 psi) so that separation of C is prevented.

(3374) French 679,531 (1930). Fried. Krupp A. G., *Production of Tools of Great Hardness.* 400 g. W are mixed with 40 g. TiC and melted in a graphite crucible, then poured into a cooled form of Cu; the mass is powdered and pressed at 4000 kg./cm.^{2} (28 tsi) in the form of small plates which are welded on a support.

(3375) U. S. S. R. 21,443 (1930). W. J. Riskin, *Tungsten Carbide on Tools.* WC is annealed and after cooling, powdered, placed on the surface of cutting tools, pressed and heated.

(3376) Brit. 345,167 (1931). Firth Sterling Co. and E. B. Welch, *Dies and Tools Comprising Tungsten Carbide.* Dies, drills, and cutters are formed of finely divided particles of hard material, such as WC.

(3377) Brit. 351,189 (1931). British Thomson-Houston Co. Ltd., *Cutting Tool.* The tool is produced by welding together a pair of wide outer metal supports plus a thin layer of cutting material of sintered hard metal alloy.

(3378) Brit. 353,663 (1931). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Alloys for Abrasive and Cutting Tools.* The cutting portion of the tool consists of a mixture of sintered hard metal particles and a soft binder, such as Cu, Ag, Co, which is capable of wetting the hard particles.

(3379) Brit. 354,112 (1931). Fried. Krupp A. G., *Tools Comprising Carbides of High Melting Metals.* W-, Cr-, Mo-, U-, V-, Ti-, Si-, or B-carbides with or without Co, Ni, or Fe are sintered or fused under flux on a foundation metal for tools.

(3380) Brit. 354,641 (1931). Fried. Krupp A. G., *Tools Comprising Tungsten Carbide Parts or Surfaces.* A flux is used during sintering of the WC part in an H_2 flame.

(3381) Brit. 359,303 (1931). British Thomson-Houston Co. Ltd. and C. F. Marquis, *Hard Metal Machine Tool.* A machine tool has a metal shank and a co-operating member of sintered carbides of a refractory metal with 3-20% of a cementing metal, such as Co.

(3382) French 706,043 (1931). Fried. Krupp A. G., *Tools.* Previously sintered carbide material is fused onto tools.

(3383) French 706,829 (1931). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Tools.* Tools are surfaced with mixtures of carbides of W, Mo, Co. The mixtures of powders are heated above the melting point of Co.

(3384) U. S. 1,812,811 (1931). B. Strauss (General Electric Co.), *Tungsten Carbide Products.* The manufacture of WC products, such as cutting tools, in an electric arc furnace entails using finely divided W and WC together with softer metal binder. The binder envelopes the carbide powder particles during ball milling.

(3385) U. S. 1,819,827 (1931). G. F. Taylor, (General Electric Co.), *Metal Stencil.* A metal stencil comprises a sintered composition of WC and Co.

(3386) U. S. 1,826,455; 1,826,457 (1931). G. J. Comstock and E. B. Welch (Firth Sterling Steel Co.), *Composition for Tools.* A material suitable for tools such as bits, drills or cutters consists of finely divided WC or ZrO_2 as major constituent in a matrix of sintered particles of high speed steel.

(3387) Brit. 380,100 (1932). Fansteel Products Co., *Hard Alloy Tools.* A tool consists of a shank with a tool bit made of an alloy containing TaC or TaB_2 and Fe, Ni or Co; the bit is coated with a solderable metal which adheres to the alloy when cold, and the bit is joined to the shank by soldering or brazing.

(3388) French 722,959 (1932). Fried. Krupp A. G., *Spinning Nozzle of Hard Metal.* The hard metal body of WC is mounted in a steel mantle containing 39-45% Ni to give the two bodies nearly the same coefficient of expansion.

(3389) French 726,718 (1932). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloy Bodies for Tools.* TaC powder is mixed with Ni and pressed in tablets, then heated and sintered at 1300° C. (2370° F.) in H_2; the tablets are welded on supports.

(3390) German 549,713 (1932). Fried. Krupp A. G., *Hollow Forms from Hard Metal Alloys.* Hollow hard metal is produced with the aid of a graphite core which is later removed.

(3391) Japan. 95,498 (1932). K. Nogami, *Hard-Edged Tools.* A mixture of WC powder and dextrin solution is fixed to the edge of the tool.

(3392) U. S. 1,891,102 (1932). C. F. Marquis (General Electric Co.), *Manufacture of Machine Tool Dead Center.* 97-80% WC and 3-20% Co are mixed together, and 1% paraffin is added; the mixture is placed in a cone-shaped die and pressed at 40 tsi. After pressing, the cone is placed in a closed C tube and heated in H_2 atmosphere to about 1375° C. (2500° F.).

(3393) Brit. 396,943 (1933). Tool Metal Manufacturing Co., Ltd., *Rotary Percussive Drills.* The drills consist of a hard metal alloy which is sintered and contains 5-12% Co.

(3394) Brit. 398,717 (1933). British Thomson-Houston Co., Ltd. and G. F. Taylor, *Improvement in or Relating to Methods of Making Wire-Drawing Dies.* Cemented refractory carbide, such as WC plus Co, is used for the manufacture of the dies.

(3395) German 578,815 (1933). Patenttreuhand-Gesellschaft für Elektrische Glühlampen m.b.H., *Büllet.* A mixture of WC with less than 20% Ni, Fe or Co and 3-7% C is used for cores of cartridges, or for heads of bullets for machine guns.

(3396) German 589,871 (1933). Allgemeine Elektrizitäts Gesellschaft, *Production of Very Thin Tool Tips or Disks.* Layers of hard carbide powders and layers of graphite are placed alternately in a form of hard glass and then pressed and sintered electrically; they may be supported by embedded wires.

(3397) U. S. 1,894,101 (1933). T. Kerr (General Electric Co.), *Machine Center.* A carbide cap for a machine center comprises 97-80% WC, mixed with 3-20% binder of a lower melting point metal, such as Co. The material is pressed in a cone-shaped die at 40 tsi, then placed in a closed C-tube and heated at 1375° C. (2505° F.) for 1½ hours in H_2.

(3398) U. S. 1,904,100 (1933). G. F. Taylor (General Electric Co.), *Wheel Dresser.* An improved wheel dresser comprises a circular radially corrugated plate having a substantially smooth outer periphery, with cemented carbide pieces of WC and Co mounted in the corrugations and the outer edge.

(3399) U. S. 1,904,568 (1933). G. F. Taylor (General Electric Co.), *Disk-Like Cutting Tool.* The tool comprises a pair of metal disks and an intermediate sintered disk of hard metal carbides and a binder.

(3400) German 595,890 (1934). Fried. Krupp A. G., *Production of Sintered Hard Alloys for Wire-Drawing Dies and Blocks.* The method consists of plasticizing the powdered mixture, alloys or compounds of metals or metalloids with a high C-content, and hot-pressing.

(3401) Swiss 171,084 (1934). G. Boecker, *Method of Making Hard Alloys for Cutting Tools and Draw-Plates.* Tools of WC, TiC, or Mo with B and Si, plus Co, V, Mg, or Al are made by finely grinding and mixing the ingredients, moistening the mixture with a volatile liquid, shooting it into a mold by means of a jet of compressed air, and sintering.

(3402) U. S. 1,944,759 (1934). A. P. Roux (General Cable Co.), *Drawing Dies.* A mixture of 30% W, 45% WC, 10% Fe, and 15% Ni is sintered to make the dies.

(3403) U. S. 1,950,355; 1,950,356 (1934). J. H. L. DeBats, *Cutting Tools from Abrasive Alloys.* Cutting tools or dies are formed in part of an abrasive alloy which may comprise 70-97% WC, combined with Ni, Co or Fe.

(3404) Brit. 422,784 (1935). G. Boecker, *Method of Making Hard Alloys for Cutting Tools and Draw-Plates. Cf:* Swiss 171,084 (No. 3401).

(3405) Brit. 426,501 (1935). Thomas Bolton & Sons, Ltd., and D. C. Bolton, *Drawing Dies.* The dies are made from WC or TaC by drilling unsintered compressed blocks by a rotary or percussive action, followed by sintering.

(3406) Brit. 430,230 (1935). Fried. Krupp A. G., *Drawing Dies. Cf:* German 615,262 (No. 3407).

(3407) German 615,262 (1935). Fried. Krupp, A. G., *Drawing Die.* The die is composed of a drawing part (core) of a very hard sintered alloy (*e.g.* 93—4—3 W-C-Co) fitted in outer supporting parts of the same sintered alloy which, however, is not so hard but more tenacious (*e.g.* 88-6-6 W-C-Co).

(3408) German 615,836 (1935). Allgemeine Elektrizitäts Gesellschaft, *Needle for Recorders.* A mixture of W, C, and Co with an organic binder is formed and sintered to form cemented carbide needles.

(3409) German 618,870 (1935). Heraeus-Vacuumschmelze A. G. and W. Rohn, *Form for Pressure Casting.* The form is produced of WC or Mo_2C with Fe, Ni, or Co as binder.

(3410) German 622,275 (1935). Stahlwerke Röchling-Buderus A. G. and A. Kropf, *Crucible.* A crucible consists of sintered TaC or ZrC with a melting point of at least 3000° C. (5430° F.).

(3411) U. S. 1,989,186 (1935). J. H. L. DeBats, *Method of Forming Rolls.* Forming rolls for metal rolling machines have working surfaces of hard alloy of Fe-nitride made by molding, compressing, and hot working Fe-nitride powder.

(3412) Brit. 449,847; 449,852; 449,853 (1936). C. A. Laise, *Tools, Dies, Nozzles, Contact Points, and Drills from Refractory Alloys.* W-, Ta-, Ti-, Zr-, Mo-, Th-, Re-carbides and/or borocarbides are obtained by carburizing, with or without boronizing with B-suboxide. Cementing metals Fe, Ni, Co, Ag, Cu may be added as reducible oxides. A plastic binder may be used as matrix and the material may be extruded or pressed into shape and sintered.

(3413) French 800,554 (1936). S. A. Union Aciers Fins, *Cemented Refractory Metal Tools.* A steel support is fastened to a tool tip consisting of two carbides of metals of the 6th group; one metal has a melting point above, and the other one below, 2000° C. (3630° F.); and they are mixed with 2-6% C and Fe as binder.

(3414) U. S. 2,027,786; 2,027,787; 2,027,788 (1936). R. Ridgeway and B. L. Bailey (Norton Co.), *Boron Carbide Articles.* B_4C powder is heated in a neutral atmosphere and pressed in molds into the shape of the final product. Examples of products made in this way are bearings suitable for spindles of textile machinery and perforated nibs for drawing wire.

(3415) U. S. 2,044,853 (1936). C. A. Laise (Eisler Electric Corp.), *Making Cutting Tools.* Metal oxides are mixed with a binder and reduced in H_2, then carburized; the product is ground, lightly compacted and molded at high temperature and highly pressed into the desired shape of the tool.

(3416) U. S. 2,053,977 (1936). G. F. Taylor (General Electric Co.), *Laminated Cemented Carbide Tool Bit.* The tool bit is composed of an outer layer of a

carbide of the fifth group and binder, a foundation layer of a carbide of the sixth group and binder, and an intermediate layer of carbides of the fifth and sixth groups.

(3417) U. S. 2,058,110 (1936). K. Schröter and H. Wolff (General Electric Co.), *Drawing Die. Cf.* German 615,262 (No. 3407).

(3418) French 47,522 (Addn.) (1937). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloy Tool Bodies.* Addition to French 726,718 (No. 3389). A tablet of TaC is joined with a tablet of WC, mixed with an auxiliary metal and then welded to the tool support.

(3419) French 813,130 (1937). N. V. Wallramite Handel Maatschappij, *Tungsten Carbide Rock Drill.* The drill is made of a cemented material containing 83.6% W, 5.4% C plus 11% Co.

(3420) German 652,077 (1937). C. Cart, *Sintered Alloys for Watches and Meters.* 92-98% WC and 2-8% Ni or Co is used for making pivots for escapements and like parts for watches and meters; up to 20% TiC may also be used.

(3421) Swiss 190,468 (1937). Vereinigte Edelstahl A. G., *Tool with Hard Metal Inserts.* The insert consists of an alloy of two hard metals, *e.g.* W and Cr, one with melting point above, and the other below, 2000° C. (3630° F.); 2-6% C and 25% auxiliary metal are added.

(3422) U. S. 2,076,356 (1937). G. F. Taylor (General Electric Co.), *Manufacture of Wire-Drawing Dies.* Manufacture of the dies involves compressing and sintering of powdered WC and Co.

(3423) Austrian 155,134 (1938). P. Marth, *Tools of Great Toughness.* The production of WC tools comprises melting the hard metal in the presence of atomic H, crushing, pressing with binder metals, and sintering above the melting point of the auxiliary metal, or pressure-sintering into the desired tool shape.

(3424) German 666,720 (1938). Heraeus-Vacuumschmelze A. G., *Production of Drawing Dies of Hard Metal.* The outer ring of hard metal is filled with another hard metal powder with a somewhat lower melting point, *e.g.* a mixture of TaC and Ni, which is pressed in the ring and sintered.

(3425) Swiss 198,462 (1938). F. Eisner, *Hard Metal Form Piece with Grooved Working Face.* The piece is produced of hard metal powder which is pressed and sintered.

(3426) French 840,352 (1939). Soc. D'Études Verrières Appliquées, *Hard Metal Alloy.* A material suitable for shock points of projectiles consists of 75-90% W, 3.5-4% C, and 5-20% Co.

(3427) U. S. 2,151,874 (1939). L. Simons (Master Wire Die Corp.), *Method of Making Wire Drawing Dies.* The films of air surrounding the particles are removed by high frequency current together with heat and pressure, to weld the particles to each other without binder.

(3428) German 691,645 (1940). Deutsche Edelstahlwerke A. G., L. Pohl and R. Kieffer, *Tool for Scraping Artificial Teeth.* The scraping tool consists of a hard metal alloy containing W, Mo, Ta, solid C, and Fe, Ni, Co, Cr as binder, the composition is sintered to convert the refractory metals into their carbides.

(3429) Swedish 109,066 (1940). A. B. Lumalampan, *Bearing Arrangement for Scales and Similar Instruments and Production Process.* The working surface of the knife edge and element contacting therewith consists of a cemented carbide.

(3430) U. S. 2,191,666 (1940). R. Kieffer (American Cutting Alloys, Inc.), *Tool Element.* A tool element for drilling and mining consists of W or Mo, up to 6% Ti, Zr or Si, 10-15% Cr, 25-34% metal of the Fe-group, and sufficient C to form a carbide with the W or Mo. The proportions of the constituents are so selected that the melting temperature of the alloy is close to the melting point of the Fe support to which it is to be welded.

(3431) U. S. 2,220,018 (1940). P. M. McKenna (McKenna Metals Co.), *Article of Tortuous Shape.* Articles of tortuous shape are produced from sintered carbide hard metal compositions.

(3432) Brit. 538,268 (1941). M. Littmann, *Projectile.* A projectile consists of a powdered mixture of 90-95% W and 5-10% C with or without an addition of Ni or

Co, which is formed into a body by pressing and sintering in a reducing atmosphere to the temperature of liquefaction of the metal particles on the surface of the body.

(3433) German 702,797 (1941). Heraeus Vacuumschmelze A. G., *Drawing Die of High Wear Resistance.* The die consists of 75-95% WC, 1-20% Mo_2C and 5% Fe or Cr, and is made by hot pressing.

(3434) German 706,249 (1941). Fried. Krupp A. G., *Cemented Carbides for Parts Subjected to Pressure and/or Moving Contacts.* The static parts of bearings, valve seats, etc. are made of WC-Co compositions with 5% TaC while the moving part consists of 35-80% WC plus Cr, Co, Ni.

(3435) German 714,013 (1941). Deutsche Edelstahlwerke A. G., *Production of Tools with Hard Metal Pieces.* The tool and the hard metal pieces are embedded in a form of graphite, whereby a space is maintained between the parts, which are then connected by pouring in molten steel.

(3436) U. S. 2,228,235 (1941). C. A. Pfanstiehl (Pfanstiehl Chemical Co.), *Pen Nib.* A hard base metal pen nib is made by using powdered Cr and C as starting materials to produce Cr_3C_2, mixing with 10% Co_2O_3, and heating to red heat in H_2 to reduce the Co_2O_3.

(3437) U. S. 2,244,053 (1941). G. J. Comstock, *Method of Forming Hard Cemented Carbide Products, e.g. Razor Blades.* The method of constructing fine edges consists of coating hard powdered metal carbides with a cementing metal, lubricating, pressing, and presintering, sawing blanks from the billet, grinding the fine cutting edges to the thickness of the hard carbide particles, and finally sintering the product.

(3438) U. S. 2,252,129 (1941). A. Kratky (Forged Carbides Inc.), *Hard Cutting and Drawing Tools.* A hard carbide or nitride is pressed into the required shapes while placed between C lamellae.

(3439) U. S. 2,258,894 (1941). N. Janco (Reed Roller Bit Co.), *Toothed Cutters for Drill Bits from Tungsten Carbide.* Particles of WC are embedded in the surface of softer metal bodies.

(3440) German 729,427 (1942). Fried. Krupp, A. G., *Cutting Tools from Cemented Carbides.* Soft metals can readily be machined with tools of different compositions, such as those containing TiC, WC, Cr, Co, Ni and Fe.

(3441) German 736,789 (1943). Heraeus Vacuumschmelze A. G., *Sintered or Hot-Pressed Tools, such as Dies, Chisels etc.* The tools are made of sintered or hot-pressed carbides and/or nitrides and/or borides of high-melting metals.

(3442) Swiss 226,062 (1943). F. P. Hoffmann, *Tools.* The tools have an edge of 60% B_4C mixed with W or Ti and are sintered together with the steel support.

(3443) U. S. 2,313,227 (1943). J. H. DeBats (Metal Carbides Corp.), *Roll for Mills.* The manufacture of rolls for metal rolling mills comprises heating and compressing a powdered mixture of WC and an auxiliary metal, such as Co or Ni.

(3444) U. S. 2,317,786 (1943). H. F. Luebbe, *Hard Metal Plates for Tools.* Pulverized WC and Fe as binder are pressed and sintered to form plates for attachment to tools; an intermediate layer of mixed crystals of Fe and Ni is used.

(3445) U. S. 2,332,071 (1943). J. Gordon (Westinghouse Electric & Mfg. Co.), *Hard Rollers Suitable for Production of Thin W-Sheets.* WC and 4-13% Co is placed in a hollow cylinder and compressed by a plunger; the mass is heated in the cylinder to about 1100° C. (2000° F.) in H_2 and thus caused to shrink, and the ingot produced is removed from the cylinder and is sintered at a higher temperature.

(3446) U. S. 2,334,755 (1943). G. F. Eglinton (Carbur Inc.), *Cutting Tool.* A two-part rotary cutting tool comprises a cutting element of a hard but relatively brittle refractory metal and a shank of a softer but less brittle metal.

(3447) U. S. 2,348,172 (1944). G. F. Taylor (Carboloy Co.), *Apparatus for Extruding Metals.* An apparatus for extruding rods, tubes, etc. consists of a mixture of hard metal carbides and a binder metal.

(3448) U. S. 2,363,406 (1944). O. G. Ferrier, *Wire Drawing Dies.* The dies have a block of hard metal and use powdered metal as the bed.

(3449) U. S. 2,395,570 (1946). P. McKenna (Kennametal Inc.), *Cutting Tool.* Powdered metals are used to make a cutting tool tip which can be clamped in place without danger of breakage and which will require a minimum of regrinding.

(3450) Brit. 584,016 (1947). S. Kryszek and Hard Alloys Ltd., *Tools Having Encased Hard Inserts.* The tool comprises an insert of hard metal encased within a metallic coating applied to the peripheral non-working surface of the insert by a spraying operation.

(3451) Brit. 586,414 (1947). Murex Ltd. and B. E. Berry, *Stud for Horse Shoes.* Ni-plated WC pins are sintered in position with a tough, heat-treatable steel powder.

(3452) Brit. 588,305 (1947). British Thomson-Houston Co. Ltd., *Resilient Cemented Carbide Rings.* The apparatus for the manufacture of the rings, which are suitable for piston rings, consists of a grooved quartz drum upon which a length of extruded cemented carbide wire can be wound while passing an electric current through it.

(3453) U. S. 2,413,989 (1947). J. L. Molner and A. Campula, *Rotary Tool.* The head of rotary files or burrs is made of cemented WC open on its rear end to take on the core of ductile metal which has an axial threaded recess.

(3454) U. S. 2,414,231 (1947). C. E. Krauss, *Cutting Tool.* A tip comprises a thin layer of sintered metal carbides and an underlayer of a cast non-ferrous alloy, bonded on one side to the carbide tip and on the other to the seat; the red hardness of the carbide layer must be greater than that of the second layer.

(3455) U. S. 2,422,636 (1947). G. F. Taylor (Carboloy Co.), *Method of Making Cemented Carbide Articles, such as Rings and Springs.* The invention relates to a method of bonding cemented carbide wires to produce resilient and flexible cemented carbide rings and springs.

(3456) U. S. 2,431,660 (1947). A. Gaudenzi (Brown, Boveri & Co., A. G.), *Turbine Blade.* A turbine blade comprises a metal foot portion and a working portion carried by the foot portion; the working portion is a sintered mixture of metal and ceramic powders; the metal content of the blade decreases as the distance from the foot portion increases.

(3457) Brit. 604,905 (1948). British Thomson-Houston Co. Ltd., *Die for Extruding Tubular Products.* A plastic carbide composition is extruded onto a graphite support, mounted detachably on the mandrel portion of the die.

(3458) Brit. 607,357 (1948). S. Kryszek, and Hard Alloys Ltd., *Mounting Drawing Dies.* Carbide drawing dies are mounted so that a hydraulic pressure can be exerted on the die to counterbalance the pressure exerted during the drawing; an arrangement for automatic regulation of the hydraulic pressure is used, which could also be adapted for carbide rolls in rolling mills.

(3459) Brit. 608,093 (1948). British Thomson-Houston Co. Ltd., *Thread Guides.* A tube of cemented carbide is bent into a single turn spiral and brazed to a steel support; the tube is made by extrusion and bent after extrusion or after sintering.

(3460) Brit. Appl. 10111/48 (1948). British Thomson-Houston Co. Ltd., *Tools of Sintered Carbides.* The tools are made from sintered carbides, crushed to -20 +325 mesh and sintered at 1600° C. (2910° F.); the porosity of the body facilitates the use of a cooling medium.

(3461) Brit. Appl. 30956/48 (1948). Hard Metals Ltd., *Rock Drilling Tools.* Carbide bits are brazed to steel shanks by means of thermosetting resins; the temperature used should not be raised above 200° C. (390° F.).

(3462) Brit. Appl. 32713/48 (1948). Skoda Works, *Molded Bodies Made of Sintered Hard Metals.* Rotary drill bits, or cutting tool tips are made with Co-rich cores (13%) and low-Co rims (5%).

(3463) U. S. 2,437,625 (1948). G. F. Taylor (Carboloy Co., Inc.), *Extruding Die.* The method of manufacture comprises pressing a plastic mixture of cemented carbides in form of a tube onto a refractory support, so that the plastic material fits loosely thereon, then sintering on the refractory support, to form a hard, dense, thin-walled tube.

(3464) Austrian 162,373 (1949). Metallwerk Plansee G.m.b.H., *Sintered Alloy.* A sintered composition, suitable for nozzles and drawing dies, contains 30-80% B_4C, with the remainder Ti.

(3465) Austrian 162,574 (1949). Metallwerk Plansee G.m.b.H., *Punching Tool.* The punch of steel has an insert of hard metal, consisting of 10-20% Co, up to 3% TiC or VC, remainder WC.

(3466) Austrian 162,575 (1949). Metallwerk Plansee G.m.b.H., *Jaws for Power Hammers.* The inserted working face of the jaw consists of 10-20% Co, up to 3% TiC or VC, remainder WC.

(3467) Austrian 162,987 (1949). Metallwerk Plansee G.m.b.H., *Stamping Tool.* The tool is produced from sintered hard metal, and is shrink-fitted in dies or holders.

(3468) Austrian 163,611 (1949). R. Kieffer and S. Heiss (Metallwerk Plansee G.m.b.H.), *Production of Drawing Dies.* The outer ring is produced by pressing and sintering of steel or Fe powders which are corrosion resistant; the cores from carbides are inserted by shrinking or upsetting.

(3469) Brit. Appl. 3,983/49 (1949). Skoda Works, *Hard Metal Alloys with High Resistance to Wear and Tear and Chemical Resistance.* Equipment for handling concentrated acids is made from cemented carbides using a somewhat lower Co content than for cutting tools, *e.g.* 80% WC, 15% TiC, 2% VC, 3% Co. The material may be nitrided for resistance to corrosion.

(3470) Brit. 618,946 (1949). The British Thomson-Houston Co. Ltd., *Cemented Carbide Piston Rings.* The piston rings are made from extruded hollow WC tubing and are given a working surface of fine capillary grooves before sintering.

(3471) Brit. 622,509 (1949). S. Kryszek, P. A. H. Meats and Hard Alloys Ltd., *Means for Mounting Liners from Tungsten Carbide.* Addition to Brit. 607,357 (No. 3458). The use of rubber, plastics, lead, are claimed as alternatives to water for exerting a compensating pressure upon carbide drawing dies.

(3472) Brit. 623,552 (1949). M. Littmann and Compound Electro Metals Ltd., *Bearings and Like Rubbing Contact Surfaces.* WC-Pb bearings are made by impregnating WC compacts having a porosity up to 40% with molten Pb. Compacts with a higher Pb content are made from mixed powders.

(3473) Brit. 624,164 (1949). Sandvikens Jernverks A. B., *Percussion Drilling Tools.* The tools have sintered carbide inserts in grooves, whereby the layers of the brazing metal, bonding the insert to the side walls, are thicker than the layer brazing the insert to the bottom.

(3474) Brit. 625,784 (1949). The British Thomson-Houston Co. Ltd., *Wire Die Nibs from Cemented Carbide.* In the pressing operation, the two core pins are kept 1/8" apart. After presintering, the nib is pierced and the entrance angle completed by means of a hard reamer.

(3475) Brit. Appl. 3194/49 (1949). A. B. Svenska Kullagerfabriken, *Manufacture of Carbide-Tipped Tools.* Carbide bits for rock drills are affixed by shrink-fitting during which additional pressure may be exerted.

(3476) Brit. Appl. 16626/49 (1949). American Electro Metal Corp., *Turbine Bladings.* The blades are made from TiC-Mo_2C powders bonded with Ni and minor amounts of Co, Cr, Fe, Si.

(3477) French 949,980 (1949). Metallwerk Plansee G.m.b.H., *Manufacture of Tools Mounted in Holders.* Wire drawing dies of WC are press-fitted into mounts of pressed and sintered Fe, which are then impregnated with Cu-base alloy. The corrosion resistance may be increased by mixing Fe powder with Pb, Zn, Cu.

C. Diamond Impregnated Compositions

(3478) German 4,042 (1878). A. L. Caverdon, *Setting and Fixing of Diamonds.* Diamond grains are coated with a thin metallic film by electroplating and binding this film to a metallic carrier.

(3479) Brit. 23,945/1895 (1895). A. W. Ringström, *Grinding and Cutting Composition.* The abrasive particles, such as diamond or corundum, are given a metallic coating, *e.g.*, by immersing in an Ag bath, to bring them into contact with positive material, such as Zn; or the particles are coated with Fe powder; the bath should then consist of a solution of $CuSO_4$ and NH_3.

(3480) Brit. 14,126/1907 (1907). C. Zeiss, *Tool for Rough Grinding Glass.* The tool consists of a tough and tenacious metal, *e.g.* Cu, with grains of diamond embedded in the superficial layer.

(3481) German 236,739 (1911). A. Schütt, *Diamond Tools.* The tools are manufactured by using an embedding metal or alloy which has the same specific gravity as the diamonds.

(3482) Brit. 175,638 (1923). S. Goldstein, *Hard Alloy Containing Diamond Dust.* Mixtures of Mo or W powder are heated with diamond dust in an electric furnace.

(3483) German 386,776 (1923). O. Diener, *Setting of Diamonds for Tools.* The diamonds are embedded in metal powder and heated and pressed, to produce a dense, solid body; a mixture of 66% Fe and 34% diamond dust yields good results.

(3484) Swiss 107,162 (1924). Hartmann & Uhlmann, *Tools for Working Precious Stones.* Diamond tools are produced by embedding the particles in a fusible metal, such as alloy Darcet.

(3485) U. S. 1,625,463 (1927). E. Gauthier (Western Electric Co.), *Diamond Lap.* Diamond particles and finely divided metallic particles are molded into a homogeneous aggregate.

(3486) French 689,027 (1930). Firth-Sterling Steel Co., *Abrasive Composition.* Abrasives, such as diamond particles, are surrounded with a hard metal composed of a mixture of WC with 5-10% Co, and heated and pressed.

(3487) Brit. 348,641 (1931). W. Müller, *Alloy.* The alloy consists of 55% W and/or Mo, 2% C, and 26-40% of binding metal with diamond particles as the abrasive.

(3488) Brit. 349,732 (1931). British Thomson-Houston Co. Ltd., *Abrasive Tools.* The manufacturing process comprises mixing a diamond dust with a binder, consisting of WC and 3-25% Fe and sintering in a mold.

(3489) Brit. 352,124 (1931). British Thomson-Houston Co. Ltd. and G. F. Taylor, *Diamond Drills.* A drill comprises diamonds embedded in a sintered matrix consisting of WC and Co; the mixture is hot pressed.

(3490) Brit. 359,637 (1931). British Thomson-Houston Co. Ltd. and S. L. Hoyt, *Diamond Tools.* A cutting tool bit consists of sintered supporting and cutting portions, which latter are composed of diamond particles mixed with WC and Co.

(3491) French 704,223 (1931). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys Containing Carbides and Diamonds.* The starting materials are mixed with diamond dust, heated and reheated to 1350° C. (2460° F.).

(3492) Brit. 368,322 (1932). P. A. Poulain, *Tools Composed of Fragments of Diamonds.* The diamond fragments are classified according to a meticulous grain measurement, then mixed in suitable proportions so that the smaller grains fill up the interstices; the ultimate interstices are filled by a binding agent, and the whole body is heated.

(3493) Brit. 382,626 (1932). P. Neven, *Solid Grinding or Abrading Material.* 20-30% diamond dust is mixed with Fe, sintered and pressed in shape.

(3494) German 546,547 (1932). R. Krause, *Grinding and Polishing of Hardest Metal Alloys.* The polishing is performed with a mixture of diamond powder and other abrasives, such as SiC; it is claimed that the use of the mixture surpasses even finest pure diamond dust.

(3495) U. S. 1,848,182 (1932). C. J. Koebel (Koebel-Wagner Diamond Corp.), *Diamonds In Grinding Wheels.* The manufacturing process involves positioning diamonds in a mass of comminuted alloy which, when heated, exhibits the property of wetting the diamond particles, coupled with inertness for C, subjecting the mass to pressure, forming shaped bodies, and then subjecting them to temperatures below the critical point at which the desirable qualities of diamond are impaired.

(3496) French 739,106 (1933). P. Neven, *Abrasive Product.* The material consists of abrasive particles or diamond splinters mixed with metal powders, *e.g.* steel, and heated to the softening temperature of the matrix under pressure.

(3497) German 583,630 (1933). Koebel-Wagner Diamond Corp., *Setting Diamonds for Tools.* The diamond dust is protected by metal powders, and sintered under

pressure at a temperature below the critical temperature of the diamonds; the binder contains 26% Mo, 27% Cu, 46% Co, and 1% Fe.

(3498) German 590,707 (1933). Allgemeine Elektrizitäts Gesellschaft, *Rock Drill.* The diamonds are embedded in a matrix of Mo_2C or WC mixed with Fe.

(3499) U. S. 1,895,926 (1933). S. L. Hoyt (General Electric Co.), *Diamond Tools.* A powdered mixture of WC and Co is formed into rod; diamond particles are embedded in one end of the rod, pressed and sintered.

(3500) U. S. 1,904,049 (1933). S. L. Hoyt (General Electric Co.), *Diamond Charged Cutting Tool Bits.* Diamond charged cutting tool bits are made from a mixture of powdered Co, WC and diamond dust, which is compacted and sintered.

(3501) U. S. 1,939,991 (1933). C. A. Krusell (Hard Metal Alloys Inc.), *Diamond Cutting Tool.* The tool is produced by molding under heavy pressure powdered WC plus a small percentage of Co, drilling holes in the block, packing diamonds together with the block under lighter pressure, and sintering.

(3502) U. S. 1,941,283 (1933). G. F. Taylor (General Electric Co.), *Diamond Drill.* The matrix into which the diamonds are set consists mainly of WC with an appreciable amount of Co.

(3503) Brit. 419,126 (1934). British Thomson-Houston Co. Ltd., *Diamond Tools.* Diamond particles are pressed together with a paste and a carbide. The paste is removed during sintering of the composite.

(3504) German 591,879 (1934). O. Ahlberndt, *Diamond Tool.* A tempered light metal alloy is used for hardening the metal carrier after embedding the diamond grains.

(3505) German 604,853 (1934). Allgemeine Elektrizitäts Gesellschaft, *Sintered Hard Alloys Containing Diamond Dust.* The alloys are obtained by powdering a carbide, mixing it with Co, sintering under pressure, pulverizing the resulting hard mass, adding diamond dust, pressing, and resintering.

(3506) Belgian 411,752 (1935). F. H. Willey, *Abrasive Tool.* The diamonds are embedded in a metallic composition with an affinity for C and heated to form carbides, which contact the surface of the diamonds.

(3507) Brit. 436,430 (1935). British Thomson-Houston Co. Ltd., *Grinding Wheels.* A grinding wheel is welded to a metallic core comprising an annular abrasive portion of a cemented carbide matrix hot-pressed with embedded diamonds.

(3508) German 611,860 (1935). Allgemeine Elektrizitäts Gesellschaft, *Grinding Tools.* A hard sintered alloy contains diamond dust and is made by mixing and hot-pressing WC, diamond dust and Co at 1375° C. (2500° F.) and 70 atm. (1000 psi).

(3509) German 622,823 (1935). Allgemeine Elektrizitäts Gesellschaft, *Cutting Tools Containing Diamonds.* Diamonds are embedded in a mixture of 34-75% Co, 13-16% Cr, and 5-40% W or Mo and then sintered.

(3510) U. S. 1,996,598 (1935). G. F. Taylor (General Electric Co.), *Abrading Tool.* An abrading tool has a cutting portion of diamond dust in a sintered binder composition of WC and Co.

(3511) Austrian 144,642 (1936). A. Kratky, *Hard Alloy Compositions.* Diamond and B are embedded in hard carbides and a layer of graphite granules coated with benzene vapor.

(3512) Belgian 416,751; 416,752; 416,961 (1936). Norton Co., *Metal Bonded Abrasive.* Diamond or B_4C is bonded with a fragile alloy of low melting-point, such as Cu-Ni or Mn-Al.

(3513) French 798,021 (1936). A. Kratky, *Method of Making Hard Cemented Refractory Compounds including Diamond.* Carbides, nitrides, borides, powdered diamond and an auxiliary metal, such as Ni, are molded into bars. These are preheated, ground to powder, mixed with glycerol, shaped and sintered.

(3514) French 803,212; 803,213; 803,214 (1936). Comp. Des Meules Norton, *Grinding Wheel.* The outer part of the fiber or Si disk, which is impregnated with resin, consists of a mixture of diamond splinters and resins.

(3515) German 626,512 (1936). P. Neven, *Method of Producing Grinding Bodies.* A method of producing grinding wheels and the like consisting of 20-30% diamond

dust and Fe powder as binding agent, comprises heating the mixture to the sintering temperature of Fe and pressing the body without heating.

(3516) German 627,862 (1936). Allgemeine Elektrizitäts Gesellschaft, *Grinding Tools*. Addition to German 611,860 (No. 3508). The diamond-containing WC-Co grinding tool is embedded in a carrier of WC and Co.

(3517) U. S. 2,027,963 (1936). J. H. L. De Bats, *Apparatus for Preparing Synthetic Carbonado Diamonds*. An apparatus for making synthetic carbonado diamonds has a shaft, a two-part body member mounted thereon which is of non-magnetic material, a carbonaceous member being susceptible of heating by inductive currents, and crucible members and an induction coil.

(3518) U. S. 2,041,346; 2,041,347 (1936). F. D. Jaques (Harrington, Shirley & Moulthrop), *Diamond Cutting Tools*. Two or more diamonds are placed in a tool body and surrounded with a powdered alloy containing Co and a metal of the Cr-group. The mixture is sintered and pressed simultaneously.

(3519) Brit. 462,809 (1937). F. H. Willey, *Diamond Tools*. Diamond is embedded in an alloy containing 60-70% W, 3-5% C, balance Ni. The diamond is graphitized on the surface, thus providing C for carbide formation during sintering.

(3520) Brit. 468,202 (1937). N. V. Philips' Gloeilampenfabrieken, *Wire-Drawing Die Alloy*. The alloy is made by sintering a powdered mixture containing 94% W, 4% Ni, and 2% Cu, with diamonds embedded in it.

(3521) Canadian 365,442 (1937). F. H. Willey, *Diamond-Containing Abrading Tool*. W, C and Ni powders containing dispersed diamonds are put in the cavity of a graphite mold and hot-pressed in steps with a spot welder.

(3522) French 818,969 (1937). N. V. Philips' Gloeilampenfabrieken, *Setting of Drawing Diamonds*. The diamond is put on a support and joined to it by sintering a metal powder around the diamond.

(3523) U. S. 2,068,848 (1937). J. H. L. De Bats and H. W. Dix (Metal Carbides Corp.), *Method of Forming Diamond-Containing Abrasive Compositions*. Abrasive compositions are formed from W and C powders, and up to 33% diamond particles, by tamping the mass in a C crucible, heating to cause first shrinkage and then expansion of the mass, and drop forging the spongy materials while still at white heat.

(3524) U. S. 2,072,051 (1937). E. Van der Pyl (Norton Co.), *Diamond Abrasive Wheels*. An abrasive body comprises diamond grains and a bonding alloy of Cu with an additional element imparting brittleness to the Cu.

(3525) U. S. 2,074,038 (1937). F. H. Willey, *Diamond Abrading Tool*. Diamond-embedded abrading tools are manufactured, using W, Ni, and C powders, distributing true diamonds throughout, and heating the mixture under pressure at 1700° C. (3100° F.) in an oxide-preventing atmosphere.

(3526) U. S. 2,077,345 (1937). E. Van der Pyl (Norton Co.), *Grinding Wheels and Method of Production*. Diamond grains are united with a bonding material, comprising 40% Al and 60% Si sintered together but not completely alloyed.

(3527) U. S. 2,077,366 (1937). L. H. Milligan (Norton Co.), *Abrasive Wheels and Method of Production*. Diamond grains are dispersed in a bond of Al and a heavier metal, *e.g.* Cu.

(3528) Brit. 479,703; 479,789 (1938). Norton Grinding Wheel Co. Ltd., *Metal Bonded Abrasives*. An abrasive body is made by mixing, pressing and sintering diamonds or B_4C grains with a powdered metal of a melting point less than 1400° C. (2550° F.), such as Cu, Sn, Ni, Al, or Mn.

(3529) Brit. 479,790 (1938). Norton Grinding Wheel Co. Ltd., *Manufacture of Abrasive Articles*. Diamond grains or B_4C are united by a bond composed of a metal alloy containing Cu and having brittle characteristics.

(3530) Brit. 485,565 (1938). Boart Products Ltd., *Improvement in or Relating to the Production of Tools Comprising Diamond*. The manufacture of an abrasive cutting tool comprises heating Co-cemented or Al-cemented bronze and diamond in a reducing atmosphere.

(3531) Dutch 44,269 (1938). Norton Co., *Grinding Wheel*. The tool is composed of diamond grains in a matrix of 30-50% Al and 50-70% Si, pressed and sintered.

(3532) Dutch 44,646 (1938). Norton Co., *Grinding Wheel.* The wheel is composed of a sintered mixture of 25% diamond grains in a matrix of Cu powder which is mixed with another metal powder, such as Sn, Ni, Al, Mg, Be.

(3533) French 829,289 (1938). Boart Products Ltd., *Diamond Tool.* The tool consists of a mixture of diamond splinters and Co, Cu, Ni, Al.

(3534) German 659,019 (1938). O. Ahlberndt, *Diamond Tool.* Improvement of German 591,879 (No. 3504) involves electrolytic anodizing for the hardening and tempering of the metal carrier.

(3535) U. S. 2,137,200; 2,137,201; 2,137,329 (1938). A. Boyer (Carborundum Co.), *Abrasive Articles.* Abrasive articles are produced consisting of diamonds, a sintered bonding agent, and a hardening agent.

(3536) U. S. S. R. 55,307 (1938). J. G. Shafran, *Diamond Tools for Grinding.* The mold is filled with a mixture of Cu powder and diamond particles, and a layer of Fe-Cu powder is pressed with the mass.

(3537) Brit. 501,074 (1939). W. Müller, *Diamond Tools.* The embedding powder for diamonds consists of Cu or bronze mixed with 15% Al or 30% Pb and heated to 1050° C. (1920° F.) under pressure.

(3538) Dutch 54,328 (1939). Deutsche Edelstahlwerke A. G., *Diamond Tools.* A mixture of 80-98% W, 1-15% Ni, 0.5-10% Cu and diamond dust is sintered under high pressure.

(3539) French 840,261 (1939). W. Müller, *Tool with Surface of Diamonds.* The matrix is composed of steel powder mixed with 20% Cu or 10% Al and sintered at 1145° C. (2090° F.).

(3540) Swedish 106,599 (1939). J. K. Smit & Sons Inc., *Method for Mounting Diamonds and the Like.* Before being mounted, the diamond is coated with a metal powder, such as Al powder.

(3541) U. S. 2,170,164 (1939). J. M. Stone and R. H. Taylor (J. K. Smit & Sons Inc.), *Making Diamond Tools.* Metal powders are placed about the diamonds and subjected to high pressure, after which the mass is heated to sinter the metal; one of the metals must have the ability to wet the diamonds.

(3542) U. S. 2,173,833; 2,173,834 (1939). W. P. Fitz-Randolph (Carborundum Co.), *Abrasive Article.* An abrasive article comprises diamonds and a sintered metal bond of Sn alloy.

(3543) U. S. 2,173,835 (1939). J. A. Boyer, W. P. Fitz-Randolph and C. G. Rose (Carborundum Co.), *Abrasive Article.* A metal-bonded abrasive article comprises abrasive diamond particles and a sintered bonding agent.

(3544) Brit. 526,241 (1940). F. W. Rolland, *Facing Tools with Abrasive Elements.* A mass of granular or powdered alloy comprising Cu and Sn is placed in a die above and in engagement with a plurality of diamonds.

(3545) Brit. 528,834 (1940). Norton Grinding Wheel Co. Ltd., *Grinding Wheel.* The wheel is produced by pressing a mixture of abrasive grains and powdered metal in different parts for the abrasive portion and the center portion in a single mold, followed by sintering. The center portion is 5-15% denser than the abrasive portion.

(3546) Brit. 531,077 (1940). Cutanit, Ltd., *Abrasive Material.* The matrix for the diamond particles consists of 2.5-5% TiC, 9-15% auxiliary metal and the balance WC.

(3547) German 697,363 (1940). Finspongs Metallverks A. B., *Wire Drawing Dies.* The inner portion of the die is made of a sintered mixture of Al, porcelain, quartz, metal carbides and diamond dust and is set in a shrunk-on ring of stainless steel.

(3548) U. S. 2,189,259 (1940). E. Van der Pyl (Norton Co.), *Diamond Grinding Wheel,* The grinder is manufactured by filling the outer portions of a mold with a mixture of diamond powder and metal powder, the inner portion with a mixture of various metal powders, and sintering the mold plus contents. The inner part of the mold is pressed 5-15% denser than the outer part.

(3549) U. S. 2,193,265 (1940). R. C. Benner and R. L. Melton (Carborundum Co.), *Abrasive Article.* The abrasive article is produced by compacting and sintering metal powders and diamond particles; the latter may be coated with Zn by spraying.

(3550) U. S. 2,194,546 (1940). L. W. Goddu and W. J. Wrighton (American Optical Co.), *Diamond Lap.* The diamond grains are placed on a wire mesh of alloy steel, the mesh being selected according to the size of the diamond particles; in order to improve their embedding, a flash coating of Cu on the wire mesh is recommended.

(3551) U. S. 2,197,655 (1940). J. A. Boyer (Carborundum Co.), *Article made from Mixed Powders.* A mixture of 10% diamond powder, 10% SiC, 72% Cu, and 8% Sn, is moistened with a solution of borax and potassium acid fluoride and poured in an outer mold; the inner mold is filled with a mixture of 20% SiC, 72% Cu, and 8% Sn, moistened with a flux; the mold and contents are then pressed and sintered.

(3552) U. S. 2,200,258 (1940). J. A. Boyer (Boron Carbide Co.), *Abrasive Article.* B_4C compositions with Cu and diamond particles as abrasive article are produced by pressure molding and sintering. The mixture may contain 10 parts diamond particles, 80-140 mesh; 10 parts Cu powder, and 80 parts crushed Cu–B_4C alloy, containing 70% Cu.

(3553) U. S. 2,205,888 (1940). C. Koebel, *Base Metal Alloy.* A matrix for diamonds is composed of alloy, comprising a mixture of metal powders containing 26% Mo, 28% Cu, and 46% Co.

(3554) U. S. 2,210,039 (1940). J. L. Petrie (Wheel Trueing Tool Co.), *Making Diamond Tools.* The process is based on the observation that at 1050-1150° C. (1950-2100° F.) without pressure, W can be caused to react with the C of the surface of a diamond to form a strongly adherent layer containing WC; the process is carried out in two heating stages.

(3555) U. S. 2,216,652 (1940). J. Romp, *Drawing Dies.* Diamonds are set in wire drawing dies with sintered metal powders, such as 95% WC with 5% Co or Ni.

(3556) U. S. 2,223,063 (1940). W. P. Fitz-Randolph (Carborundum Co.), *Abrasive Article.* A metal-bonded abrasive article comprises diamonds and a bond of Zn and Fe powders.

(3557) Australian 115,737 (1941). E. M. Andries, *Diamond Impregnated Metal.* Molten metal particles and diamond particles are combined in spray form, and the spray directed on a revolving matrix constituting the tool body, on which the mass hardens; in a second stage, pressure and heat may be applied.

(3558) Brit. 533,627 (1941). British Thomson-Houston Co. Ltd., *Manufacture of Hard Metal Alloys.* The alloys are produced from WC with 6% Co powder and 3-7% diamond dust; the mixture is heated and compressed in a mold by a predetermined stroke of a plunger and simultaneously heated by electric current, thereby compensating for any loss of heat through the pressure applying means.

(3559) Brit. 534,009 (1941). Koebel Diamond Tools Co., *Setting Diamonds.* A soft porous metallic composition is prepared by sintering 89% Swedish Fe, 6% Co, 5% Cu; the diamond is then positioned and sintered in.

(3560) Brit. 539,436 (1941). A . Nagy, *Grinding Tools.* The abrasive, such as diamond, is applied by coating the body with a greasy and sticky material, *e.g.* petroleum jelly, then applying a layer of grinding particles by dipping it into a container containing the abrasive, and finally pressing the particles into the body.

(3561) Brit. 540,392 (1941). Wheel Trueing Tool Co., *Making Diamond Tools.* The tools are prepared from a mixture of diamonds and W, wherein the W reacts with the C of the diamonds at a temperature of 1150° C. (2100° F.) in the absence of a bonding material.

(3562) French 868,203 (1941). Fried. Krupp A. G., *Hard Metal Body.* The annular body consists of an annular support of a mixture of 38-45% Ni and 62-55% Fe, sintered at 1200° C. (2190° F.) and a hard metal deposit which is composed of a carbide of refractory metal with binder and diamond splinters; both parts are sintered together at 1300° C. (2370° F.).

(3563) German 703,002 (1941). R. Krause, *Diamond Abrasive Powder.* The powder consists of a carbide with 1-5% diamond grains, whose grain size is considerably smaller than that of the carbide.

(3564) Swiss 215,460 (1941). Fried. Krupp A. G., *Boring Tool of Hard Metal.* The tool consists of a sintered core containing dispersed diamonds and a sintered mantle without diamonds.

(3565) U. S. 2,228,871 (1941). J. H. L. De Bats (Metal Carbides Corp.), *Diamond Bearing Tool and Process of Making Same.* An abrading tool containing diamonds is made by forming a diamond embedding composition from powders of 50% WC, 0.5% Cu, and remainder W, positioning the diamonds into this mixture and subjecting it to a hot-pressing operation.

(3566) U. S. 2,230,804 (1941). C. J. Koebel (Koebel Diamond Tools Co.), *Base Metal Alloy.* A setting for diamonds is composed of an alloy containing 40% Mo, 40% Cu and 20% Co.

(3567) U. S. 2,238,351 (1941). E. Van der Pyl (Norton Co.), *Grinding Wheel.* An abrasive composition containing diamond particles is bonded with a hard, friable, sintered metal bond.

(3568) U. S. 2,240,829 (1941). A. J. Bevillard (Bevil Corp.), *Cutting Tool.* A cutting tool comprises diamonds within a cast matrix, consisting of 47.5% Cu, 47.5% Ni, 3% Cr, and 2% Si.

(3569) U. S. 2,243,105 (1941). P. L. Kuzmick (J. K. Smit & Sons Inc.), *Abrasive Tool.* An abrasive tool comprises a bonded mixture of metal particles, abrasive particles, *e.g.* diamond, and a nonmetallic bond.

(3570) Belgian 444,551 (1942). Svenska Diamantbergbornings A. B., *Matrix for Setting Diamonds.* A metal with a low melting point is cast around a mixture of diamond particles and hard metal powder; the metal penetrates into the irregularities of the surfaces of the diamond particles.

(3571) Brit. 544,192 (1942). Fried. Krupp A. G., *Mounting Hard Metal Bodies.* Ring-shaped hard metal bodies which may be charged with diamonds to form a grinding ring, and contain an auxiliary metal, are fixed by welding to supporting bodies of sintered Fe.

(3572) Brit. 548,536 (1942). P. L. Kuzmick (J. K. Smit & Sons Inc.), *Abrasive Tool.* The tool is composed of a mixture of 29.6-32.13% fine Cu, 29.6-32.14% fine Sn, and 30.8-25% diamond powders, with 9.9-10.7% synthetic resin.

(3573) Dutch 54,328 (1942). Deutsche Edelstahlwerke A. G., *Tools Whose Working Surface Consists of Metal with Embedded Diamonds.* A tool for turning, drilling, or grinding, has a working surface composed of an alloy of a high melting and a low melting metal which is mixed with diamonds.

(3574) French 868,831 (1942). Elektroschmelzwerk Kempten, A. G., *Abrasive Body.* A mixture of fine powder of B and diamond splinters is formed and heated to form a compact aggregate.

(3575) German 719,777 (1942). Philips Patentverwaltung G.m.b.H., *Embedding of Drawing Diamonds.* The supporting plate and the embedding material consist of a sintered mixture of 94% W, 4% Ni, and 2% Cu.

(3576) German 720,005 (1942). G. Preuss, *Composition For Embedding Diamonds.* Diamond splinters are embedded in a mixture of approximately 80% Fe and 20% Zn. The metals are sintered under heat and pressure.

(3577) Swiss 216,730 (1942). Fried. Krupp A. G., *Sintered Material for Cutting or Grinding Bodies.* The hard material is composed of diamond powder, B_4C and/or WC and TiC embedded in a matrix of Co_3W_3C or Ni_3W_3C.

(3578) U. S. 2,270,209 (1942). E. Van der Pyl (Norton Co.), *Abrasive Article.* To a preformed relatively soft Fe backing is sintered the abrasive portion, consisting of diamond particles and a hard brittle ferrous bond of Fe, C, and Si.

(3579) U. S. 2,282,912 (1942). E. Van der Pyl (Norton Co.), *Grinding Wheel.* The composition of a grinding wheel comprises a mixture of a comminuted abrasive, such as diamond, and a comminuted metal.

(3580) U. S. 2,285,909 (1942). W. Dawihl (General Electric Co.), *Tools for Cutting and Grinding.* The tools consist of diamonds and a metallic binder, which

is composed of a chemical compound of Co, W and C in accordance with the formula Co_3W_3C.

(3581) U. S. 2,306,423 (1942). H. Bernstorff and G. Jaeger, *Grinding Body.* The manufacture of a grinding and cutting disk comprises sintering and tempering Be powder with Cu powder and diamond dust.

(3582) Brit. 556,023 (1943). Carborundum Co., *Forming Abrasive Articles.* Diamond powder or other abrasives are mixed with metal powders, *e.g.* 80% Cu, 10% Fe, and 10% Sn, and subjected to heavy pressure in a mold; the compacted shape is sintered in inert atmosphere.

(3583) Brit. 556,668 (1943). F. C. Jearum, *Diamond Tools.* Hard metal particles are charged with diamond particles by pressure or impact, and then embedded in a supporting bond in a mold of the shape under pressure.

(3584) Brit. 556,716 (1943). L. E. Van Moppes, *Diamond Tools.* The diamonds are surrounded by Fe powder and the mass is compacted by pressure, then a molten brazing metal is introduced in the interstices.

(3585) Canadian 438,346 (1943). Fish-Shurman Corp., *Abrasive Material.* A diamond abrading tool is made by sintering a mixture of diamond powder and carbonyl Fe powder with In, Au and/or Ag additions.

(3586) Czech. 72,390 (1943). (Bohem. & Morav. Protectorate). Fried. Krupp A.G., *Hard Metal Body for Boring Tools.* The body is composed of a core of hard metal in which are dispersed diamonds and a mantle of sintered metal free of diamonds.

(3587) Dutch 54,328 (1943). Deutsche Edelstahlwerke A. G., *Tool with Diamonds. Cf:* German 750,271 (No. 3606).

(3588) French 887,950 (1943). Deutsche Edelstahlwerke A. G., *Diamond Grinding Wheel.* The metallic matrix into which diamonds are embedded consists of a skeleton of Fe, Ni, or Co which is impregnated with Sn, Pb or Cu.

(3589) German 734,058 (1943). L. P. Herz, *Making Truing Tools.* The diamonds or splinters are held in position in a mold by means of thin sheets of a wire network, and metal is poured over them.

(3590) German 742,744 (1943). Fried. Krupp A. G., J. Hinnüber, and E. Ammann, *Diamond-Hard Metal Tools.* Diamonds set in cemented carbide are soldered at 650° C. (1200° F.) to a backing of Ni-Fe alloy by means of Ag solder.

(3591) German 743,121 (1943). W. Müller, *Grinding Wheel.* The diamond layer is very thin and rigid towards the work; the layer is under spring pressure so as to avoid periodic vibrations.

(3592) German 743,204 (1943). F. Sedlacek, *Small Grinding and Cutting Tools.* The tools consist of a small metallic plate with cavities which are filled with diamond splinters or SiC and bonded by electrodeposition.

(3593) Swedish 106,768 (1943). Svenska Diamantbergborrnings A. B., *Method for Setting Diamonds and Other Hard Grains in a Mounting Material and Products Thus Obtained.* Diamonds and the like are wholly embedded in a powder having a particle size so small that the particles penetrate into and fill up any surface roughnesses on the diamonds; after that, without first sintering the powder, a metal or an alloy having a lower melting point than the powder is poured into the powder mass and the resulting composite is solidified.

(3594) Swedish 109,135 (1943). Svenska Diamantbergborrnings A. B., *Method for Setting Diamonds or Other Hard Grains in a Mounting Material and Products Thus Obtained.* Method according to Swedish Pat. 106,768 (No. 3593) characterized in that the powder wherein the diamonds, etc. are embedded, is mixed with a powder or material that is not wetted by the cast metals or cast alloys.

(3595) Swiss 224,920 (1943). Elektroschmelzwerk Kempten A. G., *Production of Grinding Wheels.* Diamond dust is mixed with B_4C and heated until sintering starts.

(3596) Swiss 225,209 (1943). A. Geiser, *Grinding Wheel with Diamonds.* The wheel is composed of hornmeal, bakelite, carborundum and diamond splinters.

(3597) Swiss 228,127 (1943). Elektroschmelzwerk Kempten A. G., *Production of Grinding Wheels.* A mixture of B_4C and diamond dust is sintered *in vacuo.*

(3598) U. S. 2,319,331 (1943). J. Kurtz (Callite Tungsten Corp.), *Abrasive Article.* An abrasive article comprises diamond or SiC particles coated with metal and glass, set in a mount of sintered metal powder.

(3599) U. S. 2,328,794 (1943). O. G. Ferrier, *Wire Drawing Die.* The manufacturing process comprises setting a diamond in a wire drawing die while heating and compressing powdered Monel metal around the diamond.

(3600) Brit. 560,410 (1944). F.R. Simms and Compound Electro Metals Ltd., *Abrasive and Cutting Tools.* A mixture is formed of two metals, *e.g.* W or Mo with Ag, Al or Sn, and the diamond particles admixed; the composition is then compressed and heat treated. Instead of admixing the diamond particles, a cutting diamond may be set in position in the matrix.

(3601) Brit. 561,892 (1944). J. Ferrari, *Production of Abrasive Tools.* The production procedure consists of spraying a mixture of diamond with metal or Cu-base alloy, containing 1-10% Be with 0.25% Co.

(3602) Brit. 562,294 (1944). J. Ferrari, *Abrasive Tools.* Diamond or other abrasives are partly held by a foundation and partly by the superimposed sprayed Be alloy; the commercial British alloy "CuBe 250" may be used.

(3603) Brit. 564,723 (1944). Callite Tungsten Corp.), *Abrasive Article.* Abrasive grains, such as diamonds, B_4C or sapphire are coated with metal, glass or ceramics, mixed with bonding metal powder, pressed into shape and sintered.

(3604) German 745,685 (1944). Anonymous, *Diamond Tools Bonded with Nickel Alloys.* A Be-Ni alloy containing 2-8% Be is used to bond the diamond particles. With increasing percentages of Be, the alloy is easier to pulverize and after sintering acquires greater hardness, but loses in toughness.

(3605) German 748,633 (1944). Anonymous, *Production of Hard Metal Alloys Containing Diamonds.* The mixture is composed of whole diamonds, W powder, auxiliary metal powder and graphite in a quantity which is insufficient for a complete carburization; it is then sintered so that the W takes up C from the surface of the diamonds.

(3606) German 750,271 (1944). Deutsche Edelstahlwerke A. G., R. Kieffer and F. Rollfinke, *Tool with Inserted Diamonds.* The working faces consist of a mixture of 1-15% Ni, 0.5-10% Cu, 80-98% W and diamond splinters in a quantity of 1/5-1/20 of the metal weight.

(3607) Swiss 233,239 (1944). Deutsche Edelstahlwerke A. G., R. Kieffer and S. Heiss, *Grinding Wheel with Diamonds.* The metallic matrix for the diamonds consists of an Fe skeleton infiltrated with a softer metal.

(3608) U. S. 2,339,270 (1944). J. T. Kelleher (American Optical Co. and Neveroil Bearing Co.), *Abrading Tool.* An abrading tool comprises a mixture of Cr, Cu and abrasive powder, *e.g.* diamond, and is sintered at 1100-1360° C. (2000-2500° F.) or at 870-1050° C. (1600-1925° F.), respectively.

(3609) U. S. 2,343,957 (1944). G. Crompton, Jr. (Norton Co.), *Diamond Abrasive Wheel.* The peripheral surface of a disk is coated with liquid solder, and diamond dust is placed on a belt which leads it to the disk. An e.m.f. of 10,000 volts is produced on the insulated disk, and the diamond particles jump from the belt to the coated disk surface.

(3610) U. S. 2,349,825 (1944). J. T. Kelleher (American Optical Co. and Neveroil Bearing Co.), *Metallic Composition and Abrading Tool.* A sintered metallic bond for abrasive particles, such as diamonds, consists of a mixture of from 50 to 95% Cr, 1 to 30% Cu, and 1 to 40% Ni.

(3611) U. S. 2,352,246 (1944). R. C. Benner and W. G. Soley (Carborundum Co.), *Abrasive Article.* An abrasive article comprises abrasive grains, *e.g.* diamond, incorporated in a sintered mixture of Cu, Sn, and Pb. Diamonds comprise 3% of the total mixture.

(3612) U. S. 2,353,236 (1944). D. R. Hammill and L. Small (Service Diamond Tool Co.), *Diamond Tool.* A diamond tool for dressing or truing an abrasive wheel has a diamond-set member of a fused or sintered powdered metal matrix.

(3613) U. S. 2,360,798 (1944). R. A. Seligman, H. H. Schwarzkopf and J. G. Van Otterloo, *Diamond-Containing Abrasive Substance.* The abrasive layer consists of dust-like diamond particles secured within a hard metallic matrix formed upon a metal surface.

(3614) U. S. 2,361,492 (1944). V. T. Pare (Radio Corp. of America), *Diamond Saw.* A diamond saw comprises a number of metal blades having diamond particles embedded therein.

(3615) U. S. 2,362,979 (1944). W. T. Anderson (Contour Saw, Inc.), *Abrasive Bond.* An abrading machine has an abrasive element formed by compressing suitable metal powder impregnated with diamond dust.

(3616) Brit. 572,945 (1945). F. Calvert and A. N. Pictor, *Manufacture of Abrasive Tools.* The process comprises molding metal powders mixed with abrasives, *e.g.* diamonds, and heating the mixture by high frequency currents; the metal becomes plastic in a short time, so that complete bonding is ensured before the abrasives are disintegrated.

(3617) Canadian 441,033 (1945). Callite Tungsten Corp., *Die Mount.* A diamond die is made by setting a nib with two supporting rods in a mold, filling the mold with alloy powder consisting of 64.8% Ni, 24.3% Cu, 0.9% Cr, and 10% Ag, compacting the powders and sintering in H_2.

(3618) U. S. 2,367,358 (1945). H. Kott and M. Yawitz (Fish-Schurman Corp.), *Abrasive Composition.* Diamond particles are coated with a layer of metal of the Pt-group by electronic deposition and the diamond particles are bonded together with an Fe-C alloy; the heated alloy in the austenitic condition has a solubility for the Pt surface coated on the diamonds.

(3619) U. S. 2,367,404; 2,367,405; 2,367,406; 2,367,407 (1945). H. Kott (Fish-Schurman Corp.), *Abrasive Composition of Matter and Method of Forming Same.* Small particle-sized diamonds are embedded in a matrix of (*1*) refractory metal powder plus binder; (*2*) Pt-group metal plus pure Ni; or (*3*) Cu, Ag, or Au plus In, plus 3-10% Ni and Mn, balance Fe, with a small percentage of C. The mixtures are pressed and sintered.

(3620) U. S. 2,368,473 (1945). G. F. Keeleric, *Abrasive Article.* The surface of a blank is coated with an adhesive and diamond particles are distributed on the coating so that they are preferentially oriented with their long axes normal to the surface; then metal is applied to the coating, to enclose the particles.

(3621) U. S. 2,370,970 (1945). G. F. Keeleric, *Abrasive Article.* Diamond or other abrasive particles are mounted on a support, and metal electrodeposited over it; the layer is built up to the desired thickness.

(3622) U. S. 2,374,942 (1945). J. Kurtz (Callite Tungsten Corp.), *Die Mounting.* Diamond dies are mounted in a mixture of powdered 64.8% Ni, 24.3% Cu, 0.9% Cr and 10% Ag.

(3623) U. S. 2,376,254 (1945). R. G. Humphrey and K. W. Sample, *Abrasive Disk.* Metal powders containing carbides or borides may be bonded with diamond fragments in a grinding wheel.

(3624) U. S. 2,379,569 (1945). R. Ellis, *Abrasive Tool.* A magnetic abrasive tool utilizes powdered steel or Ni, set with diamond dust. The process consists of mixing magnetizing material with powdered abrasive and binder; pressing the mixture in a mold into a solid mass; and inserting the solid mass into a magnetic field generated by direct current.

(3625) U. S. 2,382,666 (1945). I. A. Rohrig and A. Kerstein, *Manufacture of Diamond Tools.* Diamonds are anchored in a body of matrix material with the aid of metal layers by passing the assembly through an electric current to deposit molecules of the metal on the diamond.

(3626) U. S. 2,388,020 (1945). J. F. Suwa (Fish-Schurman Corp.), *Grinding Tool.* Metal powders are used in sintering a universal type abrasive grinding tool, the mixture being composed of 5% Mn, 0.25% Au, 0.25% Ag, 10% In, balance Fe, with which is mixed 25% diamond dust.

(3627) U. S. 2,391,589 (1945). L. Nussbaum, *Abrasive Tool.* A body is formed of diamond particles bonded together by a bond which functions as a secondary abrasive and consists of a mixture of B_4C, SiC and a metallic carbide.

(3628) Brit. 575,278 (1946). J. Ferrari, *Abrasive Tools.* Diamond is partly held by a foundation of Be alloy and partly by a superimposed sprayed metal; best results are obtained with an alloy of 97.75% Cu, 2% Be, 0.25% Co.

(3629) Brit. 577,633 (1946). Callite Tungsten Corp. and J. Kurtz, *Abrasive Article.* The abrasive article, containing diamond, B_4C, etc., is produced according to Brit. 564,723 (No. 3603). The material is shaped to form a ring of rectangular section, compressed and pre-sintered; then a central metal part is placed in the ring and the brazing material inserted; sintering results in shrinking the external ring on the central part, while the brazing material is taken up by the pores of the rim part.

(3630) Brit. 578,200 (1946). American Optical Co. and Neveroil Bearing Co., *Abrading Tool.* The tool consists of a mixture of abrasive particles (*e.g.* diamonds) dispersed in Cu and Cr particles whereby the Cr particles are in excess of the Cu particles and the Cu is of an amount which, during sintering, bonds the Cr and abrasive particles into a coherent mass.

(3631) Brit. 579,661 (1946). The Impregnated Diamond Products Ltd. and F. Calvert, *Manufacture of Tools.* A steel base, *e.g.* a dished grinding wheel, and a mixture containing diamond powder are treated in two stages. The first consists of placing the base and the mixture in a mold of Cr-Ni steel, and pressing, then heating the mold to 700° C. (1290° F.), and afterwards pressing again. The second stage consists of re-sintering the product.

(3632) Brit. 580,963 (1946). E. A. Pokorny, *Diamond Tools for Grinding.* Up to 30% MnO is included in the auxiliary metal for bonding impregnated diamond tools.

(3633) Brit. 582,275 (1946). Carborundum Co., *Abrasive Article.* A grinding wheel has a facing of diamonds secured to a hard resin backing plate; the bonding material between the metal ring and back plate is a rubber sheet with perforations.

(3634) Brit. 582,808 (1946). Fish-Schurman Corp., *Abrasive Composition.* The Pt surface-coated diamond particles are heated while embedded in a powder of Fe-C, to alloy the Pt of the coating with the Fe-C alloy. The sintered alloy particles form a coherent metallic mass which is rapidly cooled and annealed.

(3635) Brit. 582,809 (1946). Fish-Schurman Corp., *Abrasive Composition.* The method of Brit. 582,808 (No. 3634) is improved by using pure Ni for the matrix, containing not over 0.30% C, and Rh-surface coated diamond particles. Ni is superior as it is acid- and oxidation-resistant; this is important if aqueous coolants are used during grinding.

(3636) U. S. 2,395,461 (1946). B. C. Chandler, *Metallic Bonded Abrasive Articles.* In a method of forming diamond dust impregnated cylindrical drills, metal powders are used as a binder.

(3637) U. S. 2,396,015 (1946). A. Liden and O. Malmborg (Svenska Diamantbergborrnings A. B.), *Method of Setting Diamonds or Other Abrasives.* Diamond particles are packed into a powder having such small particles that they enter the cavities in the surface of the diamonds, whereupon a cast or poured metal is introduced into the body, which is not sintered.

(3638) U. S. 2,401,087; 2,410,512 (1946). O. V. Lindquist, *Diamond Drill Bit.* Powdered metal is used in the manufacture of an improved diamond drill bit.

(3639) U. S. 2,405,086 (1946). A. J. Bevillard (Bevil Co.), *Abrasive Wheel.* Powdered Cu, Ni, Fe, Ti, etc., are used as a matrix for diamond particles in an abrasive wheel.

(3640) U. S. 2,411,867 (1946). B. Brenner, *Diamond Tool.* A thin coating of Pt is formed by heat precipitation on each diamond particle; the uniform distribution of the diamonds over the work surface of the tool is effected by pouring the coated diamonds into the electrolyte, so that they fall through the bath onto the surface of the tool.

(3641) U. S. 2,413,084 (1946). K. Sommer, P. Maca, E. Edwards and W. Budig, *Glass Drilling Apparatus.* Diamond particles are embedded in Ag-solder, consisting of Ag and brass powder; a mixture of 25% solder and 75% diamond dust is retained in an annular row of V-shaped notches at the bottom edge of the drill, and fused therein with an oxy-acetylene torch.

(3642) Brit. 586,356 (1947). American Optical Co. and Neveroil Bearing Co., *Abrading Tools.* The diamond lens grinding tool described in Brit. 578,200 (No. 3630) is bonded with Cr-Cu-Ni in proportions of 65:15:20 or 60:20:20.

(3643) Brit. 586,959; 586,960 (1947). American Optical Co. and Neveroil Bearing Co., *Abrading Tools.* Crushed diamonds and metal particles are bonded by sintering. The bonding mixture consists of 40-50% Ni, 30-45% Cu, 10-20% Sn; or 83.5% Co, 16.5% Cu. The backing support is made of the same sintered mixture.

(3644) Brit. 590,325 (1947). F. Calvert and A. N. Pictor, *Abrasive Tool.* Diamond tools are made by hot pressing a powdered mixture of diamond and steel at 860-960° C. (1580-1760° F.) and 7½ tsi, using high frequency heating.

(3645) Brit. 591,481 (1947). The British Thomson-Houston Co. Ltd., *Diamond Tools.* A plurality of similar dome-shaped arrangements of diamonds are embedded in a sintered matrix, consisting of hard metal carbides impregnated with Cu.

(3646) Brit. 593,908 (1947). Fish-Schurman Corp., *Abrasive Composition.* Diamond-impregnated tools are bonded with carbonyl Fe and small additions of Cb, Ni, In, Cu or Au.

(3647) French 929,327 (1947). Wheel Trueing Tool Co., *Manufacture of Diamond Tools.* A mixture of W and diamond powder is pressed at 1000 psi, then sintered in H_2 for 30 min. at 1100° C. (2010° F.). The porous compact is impregnated with brazing material, *e.g.*, 75% Cu, 5% Zn, and 20% Ag, by heating the product to 1145° C. (2100° F.) for 10 min.

(3648) U. S. 2,414,226 (1947). S. J. Everett, *Metal Bonded Abrasive Tool.* Wires are dipped in a mixture of trichlorethylene and oil, then rolled in diamond powder, cut to length and inserted in a metal sheath. The oil is removed by heating and the diameter of the assembly reduced by drawing and annealing; then the outer sheath is removed.

(3649) U. S. 2,423,314 (1947). W. A. Felker, *Abrasive Tool.* The diamond grains are set in the notches of the body with a matrix under heat and pressure to bond them with the body by sintering.

(3650) U. S. 2,428,823 (1947). M. G. Wright, *Producing Drill Bits.* A rotating stock is sprayed with a mixture of molten metal and diamond particles; the bore of the stock is shielded from the deposit of matter thereon. The mass deposited on the stock is cooled, and spraying is continued until a measured amount has been deposited.

(3651) Brit. 601,428 (1948). Wheel Trueing Tool Co., *Core Bits.* A series of spaced nibs is hot-pressed in a C die from a mixture of diamond dust and -300 mesh H_2 reduced Fe powder. The temperature is then raised to 980° C. (1796° F.), when the nibs are impregnated with molten bronze; then the body of the core bit is brazed on while the nibs are in the die.

(3652) Brit. 604,591 (1948). Callite Tungsten Corp. and J. Kurtz, *Oxidation Resistant Alloy for Diamond Dies.* Diamond dies for hot drawing of wire are mounted in a sintered alloy consisting of 64.8% Ni, 24.3% Cu, 10% Ag, and 0.9% Cr.

(3653) Brit. Appl. 29358/48 (1948). Koebel Diamond Tool Co., *Core Bits.* The diamonds are mounted in a sintered matrix.

(3654) French 935,636 (1948). Svenska Diamantbergborrnings A . B., *Diamond Impregnated Tools.* Grinding wheels are made by bonding the diamond dust in a matrix of 30-60% Co, 8-28% Sn, balance Cu, and hot-pressing at 12 tsi and 750° C. (1380° F.), or at 3 tsi and 900° C. (1650° F.).

(3655) U. S. 2,442,153 (1948). E. Van der Pyl (Norton Co.), *Band Saw with Diamond Abrasive Teeth.* The spaced holes have a plurality of metal bonded diamond abrasive teeth attached to the edges between the cut-outs.

(3656) U. S. 2,452,478 (1948). G. W. Lucas (Carboloy Co. Inc.), *Diamond Tool.* The tool has a plurality of layers, each consisting of spaced diamonds embedded in a matrix of metal carbides, impregnated with Cu; the number of diamonds in each layer are equal and are spaced equal distances.

(3657) Austrian 162,120 (1949). O. Scheid, *Production of Diamond Grinding Wheels.* Diamond particles are mixed with synthetic resin or shellac to electrically isolate them; by electrolysis, metal deposits between the diamond particles are produced that bond them together and onto the metallic body.

(3658) Austrian 164,065 (1949). Metallwerk Plansee G.m.b.H., *Diamond Tool for Grinding.* The porous matrix for the diamonds is impregnated with Cu, Sn or Pb.

(3659) Brit. 614,396 (1949). T. W. Penrice, R. F. Knowlson and J. K. Smit, *Coating of Diamonds.* The diamonds are cleaned chemically and then physically by exposure to an ionic current. The coating is then applied either by evaporation or sputtering of Pt or Cu.

(3660) Brit. 615,731 (1949). R. F. Knowlson and J. K. Smit, *Abrasive Article.* A 90-10 matrix is used with 15-40% Pt-coated diamond powder and 2-3% graphite, the mixture is pressed and sintered in cracked NH_3 at 850° C. (1560° F.) for ½ hr.

(3661) Brit. 616,901 (1949). Norton Grinding Wheel Co. Ltd., *Making Diamond Abrasives with Steel Bond.* An allov steel bond is obtained from mixed powders, and an excess of C is used for the preventing of graphitization of the diamonds. Composition of the alloy steel is 93% Fe, 3.5% Ni, 1.5% Cr, 1% Mo, 1% graphite.

(3662) Brit. 617,741 (1949). Svenska Diamantbergborrnings A. B., *Diamond Impregnated Tools. Cf:* French 935,636 (No. 3654).

(3663) Brit. 626,992 (1949). The British Thomson-Houston Co. Ltd., *Metal Coated Non-Metallic Bodies.* Diamonds are coated with Ti-Cu alloy for brazing to cemented carbide. The alloy coating is obtained by painting the diamonds with an alcohol suspension of a mixture of 26 parts Ti-hydride and 5 parts Cu powder, and heated in pure H_2, to form the Ti-Cu alloy.

(3664) French 948,530 (1949). J. Ivaldi, *Dental Instruments.* Grinding wheels for dental purposes are made from plastic-bonded diamond or WC.

(3665) U. S. 2,467,596 (1949). W. R. Pratt (Bevil Co.), *Manufacture of Abrasive Wheels.* The wheel may be rimmed with a preformed annular compact composed of finely divided Ni (passing a 325 mesh screen), and containing a uniform distribution of small diamond particles.

(3666) U. S. 2,471,132 (1949). A. C. Wickman (A. C. Wickman Ltd.), *Method of Producing a Sintered Abrasive Body.* The sintered abrasive body is prepared by grinding a wet mixture including 93% by weight of finely divided calcined Al_2O_3, 4.2% by weight of bentonite containing 57.7% by weight of SiO_2, and 2.8% by weight of fluorspar. The product is dried and formed into granules and then molded with diamond particles. The molded product is then sintered under combined heat and pressure.

(3667) U. S. 2,488,151 (1949). D. E. Webster (Norton Co.), *Method of Making Abrasive Teeth.* A diamond abrasive body consists of 18.6% Sn and 81.4% Cu, as separate powders, together with a variable concentration of diamonds. The diamond abrasive piece is secured to a piece of Fe metal by means of Ag solder disposed between complementary surfaces on the abrasive piece and Fe metal. The surfaces are pressed together and placed in a loop of a high frequency induction machine until the Fe piece is red hot, but removed before the abrasive piece reaches red heat.

D. Miscellaneous Abrasives

(3668) U. S. 262,034 (1882). D. Forbes, *Powder for Polishing Glass.* An abrasive glass-polishing powder is composed of Pb, Sn, and Cu, calcined and mixed with water to a pasty condition.

(3669) U. S. 373,239; 466,277 (1887). C. M. Lindsey, *Polishing Material.* An abrasive grinding and polishing material comprises pulverized steel.

(3670) U. S. 511,779 (1893). W. L. Kann, *Polishing Material.* An abrasive grinding and polishing material comprises fractured steel mixed with a softer or more friable material, such as rouge.

(3671) German 79,993 (1895). E. Offenbacher, *Production of Abrasives.* Molten steel is poured out in a thin layer into a groove, in which it is separated by vapor jets into small balls, for use as an abrasive.

(3672) U. S. 604,569 (1898). A. Ringstroem and N. E. Frykholm, *Grinding Material.* An abrading material is coated with metal powder and bonded with molten metal.

(3673) German 128,448 (1900). J. Rieder, *Electrolytic Binding of Abrasives.* Abrasives, such as emery or SiC, are made electrically conductive by mixing with graphite; then the grains are bonded with a metal by using it as a cathode.

(3674) U. S. 755,589 (1904). M. Waddell, *Razor Strops.* A cake or stick to be rubbed on razor strops to improve their quality comprises finely divided and oxidized Al mixed with hard grease, such as cocoa butter.

(3675) U. S. 779,639 (1908). E. G. Case, *Fastening Abrasive Material To Metal.* Powdered SiC is distributed over the surface of a metal body, which is subjected to an electro-plating process, so that the abrasive particles are embedded into and fastened by the plating.

(3676) U. S. 918,069; 934,412 (1909). C. J. Marius and F. G. Marius, *Polishing Substance.* Particles of an abrading material are cast in a metallic matrix to form an abrading mixture.

(3677) U. S. 1,024,156 (1912). T. Sottile, *Composition of Matter.* An abrasive composition to be used on razor strops comprises water, powdered steel, axle grease, powdered glass, and anisette oil.

(3678) U. S. 1,057,187 (1913). H. Tolputt, *Polishing Mixture.* A polishing composition consists of a hydrated oxide and powdered metallic Pb incorporated with an agglutinant binder, such as stearin.

(3679) U. S. 1,159,264 (1915). A. Pfaff, *Abrasive Refractory Lining Material.* The material consists of a burnt mixture of powdered ZrO_2 and SiC.

(3680) U. S. 1,216,643 (1917). M. Yasuda, *Composition for Polishing Iron.* A composition used for cleaning and polishing Fe is composed of powdered Al, dehydrated alum and powdered crystalline SiO_2.

(3681) German 345,541 (1921). Optische Anstalt C. P. Goerz, A. G., *Method for the Producing of Grinding Tools.* Metal powder particles are bonded together with the abrasive particles by fritting under combined high pressure and heat.

(3682) U. S. 1,624,783 (1927). A. B. Fisher, *Polishing Composition.* A polishing composition comprises an intimate mixture of finely divided metal powders, pumice and oil.

(3683) U. S. 1,632,909 (1927). S. R. Mason (Western Electric Co.), *Cleaning of Metal Parts.* A buffing compound comprises an abrasive, binder and powdered Al.

(3684) U. S. 1,931,370 (1933). I. Bethel (Norton Co.), *Polishing Material.* An abrasive tool is composed of a molded, compacted mixture of a granular metal and granular abrasive material held by a brittle, non-metallic bond.

(3685) Canadian 438,539 (1934). Minnesota Mining & Mfg. Co., *Abrasive Manufacture.* For the production of sandpaper, a web is coated and contacted with a surface layer of abrasive particles; an electric field is used for magnetic orientation of the particles.

(3686) U. S. 1,956,905 (1934). E. S. Merriam, *Preformed Abrasives.* The material is composed of grains of a material of normally non-abrasive character bonded together by a continuous bond of Al_2O_3.

(3687) U. S. 1,983,082 (1934). W. L. Howe and R. H. Martin (Norton Co.), *Article of Bonded Granular Material.* The manufacturing process comprises molding a mixture of abrasive grains and a raw bond in such a manner that after the bond has matured, the abrasive grains, the bond and the pores will each constitute a predetermined volume percentage of the article.

(3688) U. S. 2,020,117 (1935). A. E. Johnston (Calibron Products Inc.), *Cutting Tools, Particularly Dental Tools.* A working head of magnetic material is provided with a recessed layer of non-metallic material; the recesses contain abrasives, secured to the body by electrodeposition.

(3689) U. S. 2,027,087 (1936). O. G. Buckner (Behr-Manning Corp.), *Abrasive Sheet.* An abrasive sheet is produced by showering magnetically coated abrasive particles in a magnetic field on a sheet having an adhesive surface.

(3690) Canadian 370,120 (1937). Norton Co. and E. Van der Pyl, *Abrasive Wheel.* The abrasive is produced by alloying with Cu a metal which forms a brittle alloy and casting ingots of this alloy, crushing the ingot to powder, adding abrasive grains and a readily oxidized metal powder, and pressing and sintering the mixture.

(3691) U. S. 2,090,274 (1937). P. H. Walker and A. H. Prey (Carborundum Co.), *Cutting and Grinding Tools.* The abrasive tools consist of 50% green SiC crystals and at least 40% pores.

(3692) U. S. 2,135,926 (1938). W. Vanlandingham, *Razor Hone.* A razor hone comprises a molded body of S containing finely divided Al carborundum, and lampblack.

(3693) U. S. 2,136,931 (1938). R. C. Benner and G. I. Easter (Carborundum Co.), *Abrasive Article.* Abrasive articles are produced by forming and sintering a mixture of amalgam-coated abrasive particles with a metal powder free from Hg.

(3694) U. S. 2,145,888 (1939). H. Moulton (American Optical Co.), *Abrading Tool.* An abrading tool comprises a sintered mixture of pulverized metal and abrasive particles secured in grooves in the base of tool.

(3695) U. S. 2,173,462 (1939). H. W. Wagner and K. F. Whitcomb (Norton Co.), *Grinding Wheel.* The wheel consists of a mass of bonded granular abrasive material and an integral inner zone which is continuous and imperforate at the wheel center; the inner zone has greater strength than the outer zone, and is of such size that the wheel can be safely rotated.

(3696) U. S. S. R. 56,003 (1939). B. Ormont and M. I. Shafran, *Applying Loose Abrasives to Grinding Disk.* B_4C and SiC on the surface of a grinding wheel are briquetted with a fat as binder; the disk is then wetted with kerosene to dissolve the binder, so that a thin layer of abrasive remains on the disk.

(3697) U. S. 2,197,655 (1940). J. A. Boyer (Carborundum Co.), *Abrasive Articles Such as Abrasive Wheels.* Abrasive hard metal and compound particles are bonded by a solid solution alloy. Sintering is performed at temperatures below the melting point of the entire alloy, where a portion of the metal only is molten.

(3698) German 703,002 (1941). R. Krause, *Grinding Powder.* A grinding powder consists of metal carbides and 1-5% diamond dust; the grain size of the diamond dust is smaller than the grain size of the carbide.

(3699) U. S. 2,237,254 (1941). R. G. Humphry and R. M. Sample, *Abrasive Disk.* The disk consists of woven warp and weft wires as base member, surrounded with an annular mass of a metal-bonded abrasive composition.

(3700) U. S. 2,254,549 (1941). L. Small, *Sintered Metal Compositions, such as Matrices for Abrasives.* The material consists of Fe or Ni plus a metal-hydride; examples are (*1*) 70% Fe, 9% Cu, 9% Cu-Ti eutectic, 9% Ti-hydride, and 3% C; and (2) 49.2% Ni, 38.4% Zr-Ni eutectic, 9.8% Zr-hydride, and 2.6% C.

(3701) U. S. 2,258,774 (1941). J. N. Kuzmick (Raybestos Manhattan Inc.), *Abrasive Tool.* Products contain abrasive particles of metal powders bonded with a synthetic resin.

(3702) U. S. 2,292,991 (1942). G. Crompton (Behr-Manning Corp.), *Flexible Abrasive Product.* A flexible abrasive product is produced by a combined soldering and rolling process, whereby the abrasive grains are affixed to the metal sheet.

(3703) U. S. 2,301,721 (1942). E. Van der Pyl (Norton Co.), *Floor Products.* Abrasive grains are bonded with a sintered metal bond formed of metal powders to give antislip properties to a floor product.

(3704) U. S. 2,332,241 (1943). R. H. Lombard and L. H. Milligan (Norton Co.), *Grinding Wheel.* A batch composition for grinding wheels may contain, in addition to clay and abrasive, a small percentage of Al powder.

(3705) U. S. 2,336,001 (1943). J. T. Eash (International Nickel Co.), *Abrasive Material.* A metallic blasting and abrasive material incorporates powdered Si, Ni and Cr.

(3706) German 743,820 (1944). Fried. Krupp A. G., *Material for Grinding and Polishing.* The powdered or bonded abrasive consists of Be_2C and/or Be-B_4C, and is suitable for work on cemented carbides.

(3707) U. S. 2,339,208 (1944). E. Van der Pyl (Norton Co.), *Flexible Abrasive Product.* Abrasive grains are embedded in a sintered metal bond comprising a Cu-Sn alloy secured on a flexible sheet metal backing.

(3708) U. S. 2,358,459; 2,358,460 (1944). J. T. Kelleher (American Optical Co. and Neveroil Bearing Co.), *Abrading Material.* An abrading tool comprises abrasive particles uniformly dispersed throughout a sintered mixture of (*1*) 50% Ni, 30-45% Cu and 10-20% Sn; or (*2*) 75-90% Co and 10-25% Cu.

(3709) Brit. 566,661 (1945). F. R. Simms and Compound Electro Metals Ltd., *Grinding and Cutting Material.* WC is used as the abrasive material according to the method of Brit. 560,410 (No. 3600); 3-10% WC is recommended in a matrix of 90% W, 4% Cu, and 6% Ni.

(3710) U. S. 2,371,700 (1945). H. C. Martin and F. A. Upper (The Carborundum Co.), *Abrasive Articles.* The articles consist of abrasive grains and a bond of phenol resin modified by a metal, *e.g.*, Ti, V, Mn, Cr, Fe, Co, Ni in finely divided form.

(3711) U. S. 2,377,995 (1945). L. Coes (Norton Co.), *Grinding Wheel.* Powdered Fe-pyrite is used as a pore filler in a vitrified grinding wheel which may contain SiC.

(3712) U. S. 2,381,413 (1945). H. H. Wolff (A. B. Hammarbylampan), *Process for Making Grinding Surfaces.* Powdered hard metals mixed with Cu are used in making a lining for a charge container used for grinding metal.

(3713) U. S. 2,388,080 (1945). F. H. Riddle (Champion Spark Plug Co.), *Alumina and Silicon Carbide Compositions.* A mixture of 11-29 parts SiC to 100 parts Al_2O_3 is formed and fixed to produce abrasive and non-conducting wear resistant material.

(3714) Brit. 575,753 (1946). Hard Metal Tools Ltd. and B. Westmoreland-White, *Hard Composition.* Composition useful as an abrasive contains 93% calcined Al_2O_3, 4.2% bentonite, and 2.8% fluorspar mixed in a ball mill for 3 days, using balls of sintered WC; the finished powder was found to contain 7.5% WC and 0.5% Co.

(3715) Brit. 578,356 (1946). Carborundum Co., *Abrasive Materials.* Pressings of finely divided α-Al_2O_3 with 1-2% TiO_2 and other oxides are sintered at 1700-2000° C. (3100-3630° F.).

(3716) U. S. 2,393,047 (1946). H. J. Krase (Monsanto Chemical Co.), *Drilling of Oil Wells.* A finely ground ferro-alloy is suspended in an aqueous medium to produce a well-drilling mud-laden fluid of abrasive characteristics.

(3717) U. S. 2,404,598 (1946). J. F. Sachse (Metals Disintegrating Co. Inc.), *Abrasive Oxide-Base Composition.* The alloy is made from a metal which, after oxidation, acts as an abrasive, and from an auxiliary metal alloy which is powdered, oxidized, and then reduced in an atmosphere in which the abrasive metal oxide is not reduced.

(3718) U. S. 2,409,363 (1946). A. Kratky, *Grinding and Polishing Tool.* Metal powders may be added to the grinding powders used with a tool for polishing lenses, jewels, hard carbides, etc.

(3719) Brit. 591,839 (1947). Micromatic Hone Corp., *Abrasive Articles.* A porous abrasive article is produced from clay bonded with metal, *e.g.*, Al, and SiC. The article is finished by impregnating with a gelatine solution under vacuum and curing with formaldehyde.

(3720) Brit. 594,068 (1947). S. Francis, *Hard Composition.* Into Al_2O_3 powder is incorporated a small amount of an alloy of at least two of the following metals: W, Mo, Ta, Rh, Os; the product is fused and reground and mixed with a further amount of these metals, to which 20% of Cr, Ni, Co, Fe may be added. BeO may be used as a plasticizer.

(3721) Swiss 242,663 (1947). Diametal A. G., *Grinding of Metal Pins.* The pins are ground by a rotating sintered abrasive disk which consists of Co, Ni, Mn, or Fe as a binding metal, a hard oxide, *e.g.* corundum, ruby, or sapphire, and a hard material, *e.g.* topaz or metal carbides.

(3722) U. S. 2,414,226 (1947). S. J. Everett, *Metal Bonded Abrasive Tool.* The tool is produced by dispersing an abrasive powder in a matrix and inserting in a

ductile sheath, consolidating the matrix by elongation of the sheath and reducing the cross-sectional area, then removing the sheath from the wire or rod.

(3723) U. S. 2,424,645 (1947). H. N. Baumann and R. C. Benner (Carborundum Co.), *Fused Aluminum Oxide Crystalline Material.* An abrasive fused product comprises crystals of α-Al_2O_3 associated in a fused matrix of an artificial spinel of $RO\,R'_2O_3$ in which the R'_2O_3 forming metal may be Al, and the RO forming metal consists of Mn, Co and Ni.

(3724) Brit. 602,801 (1948). Industrial Research Corp., *Improvements in Cutting, Grinding or Polishing.* A novel process of micro-abrading involves abrasive particles which are located either in the tools or suspended in a liquid; the particles are brought into contact with the material to be treated while under the effect of magnetostriction or ultrasonics. The tool is made by powder metallurgy techniques and used for grinding lens and mirror surfaces.

(3725) U. S. 2,434,749 (1948). E. D. Teague (Norton Co.), *Abrasive Tool.* Manufacture of the tool comprises supplying a thin layer of metal powder to a surface of a mold ring, filling the mold space contiguous to the metal powder with a mixture of abrasive grains and a non-metallic bond and heating the assembly, thus causing the metal powder to impregnate the adjacent portion of the abrasive bond composition.

(3726) U. S. 2,442,155 (1948). W. W. Weese, *Bore Cleaning Bullet.* The material consists of a mixture of metal powders and abrasive powders, having an exterior surface containing abrasive grains.

(3727) U. S. 2,443,315 (1948). H. E. Hall (Metals Disintegrating Co.), *Making Abrasive Articles.* The material consists of abrasive grains of a metal oxide attached to particles of a matrix metal and is formed by reacting an alloy of the two metals with an oxide of the matrix metal. For example, a moldable Fe powder containing Al_2O_3 grains is prepared from a mixture of 55 parts of an 55/45 Fe/Al alloy and 100 parts FeO; the mixture is ground and heated to 1000° C. (1830° F.) in an atmosphere of 16% H_2, 30% CO, and 54% N_2.

(3728) U. S. 2,443,698 (1948). J. Y. Snyder (Wedgeplug Valve Co.), *Metal Grinding Composition.* The composition contains Al_2O_3 incorporated in butylene polymer, plus petroleum lubricant, fatty acid and resin.

(3729) U. S. 2,457,012 (1948). F. A. Upper (Carborundum Co.), *Abrasive Article.* Manufacture of the article comprises compressing an assembly of fibrous sheet material, which contains abrasives, to form a body, and applying a coating of adhesives to the re-entrant surfaces provided in the abrasive body.

(3730) Austrian 162,627 (1949). Metallwerk Plansee G.m.b.H., *Granular Substance for Grinding Tools.* The abrasive powdered material is produced from sintered hard metal, *e.g.*, 85% TiC, 10% Mo_2C, and 5% Ni, which is crushed to 0.1-3 mm.

(3731) U. S. 2,463,678; 2,463,679 (1949). J. P. Buckey (John T. Kilbride), *Abrading Element and Method of Making Same.* During abrading of metals, C particles are momentarily placed under great pressure and heat, considering the size of the particles, with the result that each particle becomes a cutting and abrading agent unequalled by any substance except the diamond. Products are suitable for grinding sintered carbides and other powder-metal compositions. Operative life of a grinding wheel is claimed to be increased seven times in one case.

3. ELECTRICAL MATERIALS AND PRODUCTS

A. Contacts, Electrodes and Bearings

i. Refractory Metal and Compound Base Composites

(3732) German 231,231 (1911). Allgemeine Elektrizitäts Gesellschaft, *Electrode for Arc Lamps.* The electrode consists of TiC with a small amount of Cr_3C_2.

(3733) Brit. 109,870 (1917). A. J. Liebmann, *Electrical Contacts.* A mixture of C, Cu, and W powder is used for the formation of electrical contacts and brushes for dynamo-electric machines.

(3734) Swiss 82,133 (1920). A. Scintilla, *Contact for Circuit Breakers.* The contact is composed of W or Mo mixed with Pd or Au.

(3735) German 366,865 (1922). International General Electric Co., *Heavy Duty Bearing and Contact Metal.* Bearing metal, such as for electrical contacts is composed of finely divided W or Mo and a soft metal as Cu.

(3736) U. S. 1,469,043 (1923). C. A. Laise, O. C. Hollopeter (Independent Contact Manufacturing Co.), *Making Electrical Contacts.* The contacts are manufactured by introducing a joining material containing W powder between the Ni base and the face plate of a refractory metal, and heating them together to welding temperature.

(3737) Belgian 330,643 (1925). Soc. D'Electricité et de Mécanique, *Metallic Composition.* Compositions to be used as contact material are produced by presintering porous metal bodies of W which are then immersed into and impregnated with molten Cu in H_2 atmosphere.

(3738) German 436,678 (1926). Allgemeine Elektrizitäts Gesellschaft, *Electrode.* The electrode consists of sintered Mo or W impregnated with Cu to form a homogeneous body.

(3739) U. S. 1,582,024 (1926). G. D. Bagley (Electro Metallurgical Co.), *Process for Uniting Metals.* A layer of Ni is melted on the bottom of a graphite crucible, and W powder is dissolved in it to form a W-Ni alloy. Cu is fused on top of the alloy to form a Cu-Ni alloy. After cooling, the two parts of the ingot are united by heating (brazing). The material is used for spark gap electrodes.

(3740) German 469,433 (1928). Stahlwerke Röchling-Buderus A. G., *Production of Bodies of High Electrical Resistance.* A 3:2 mixture of Ta powder with graphite is mixed with binder, *e.g.*, glycerine or glucose, formed and sintered at 2000-3000° C. (3630-5460° F.) under pressure.

(3741) German 497,472 (1930). Siemens-Schuckertwerke A. G., *Vacuum Switch.* The switch has one contact of WC or TaC.

(3742) U. S. 1,751,780 (1930). J. A. Weiger (P. R. Mallory & Co. Inc.), *Electrical Material For Current-Traversed Bearings.* A sleeve member of W is impregnated with a relatively light, low melting point metal (Cu) plus a small amount of hardening agent to impart hardness and self-lubricating characteristics.

(3743) Brit. 349,400 (1931). Fried. Krupp, A. G., *Electrically Heated Contact Pieces.* The pieces are formed of WC alloy with a curved bore through which a Cu wire is passed and electrically heated without interruption of the current.

(3744) U. S. 1,807,581 (1931). W. Bates (The Ohio Instrument Manufacturing Co.), *Electrical Contact Terminal.* The piece contains 50-95% of a metal group consisting of W and Mo together with both Cu and 0.2-5% Si.

(3745) German 554,931 (1932). F. Skaupy, *Electric Contact.* The contact is composed of TaC or CbC, and the byproducts are vaporized.

(3746) German 561,457 (1932). Fried. Krupp A. G., *Contact Bodies from Hard Metal.* A WC body possesses a bent borehole for the contact wire and is obtained by first incorporating into the powder mass a bent Cu wire, pressing the mass, and then sintering it at a temperature sufficiently high to allow the Cu wire to melt and exude from the body.

(3747) U. S. 1,848,438; 1,860,793 (1932). J. A. Weiger and G. N. Sieger (P. R. Mallory & Co. Inc.), *Electrical Contacting Element.* A porous body of hardened high melting metal, like Mo or W, for use as contact material, includes 0.5% C, or N as alternate, and an auxiliary metallic constituent of Ag or Cu is used to impregnate the porous body.

(3748) French 747,951 (1933). N. V. Molybdenum Co. and P. Schwarzkopf, *Composite Material for Electrical Contacts.* W, Mo, or Ta powders are mixed with Cu, Ag, Pb, Pt, or Zn, heated and pressed, crushed and mixed with Ti, Va, or Zr; the mixture is then formed and sintered.

(3749) Brit. 410,268 (1934). N. V. Molybdenum Co., *Improvements in Electric Discharge Vessels.* A grid-electrode for electric discharge vessels consists of 15-40% Mo or W and 10-30% Fe and at least 40% Ni, and may also contain Mg, Va, Si, C.

(3750) U. S. 1,958,338 (1934). C. B. Gwyn, Jr. (P. R. Mallory & Co., Inc.), *Make-and-Break Contact.* The contact has a W face substantially freed from material in the grain boundary, this condition is obtained by subjecting the W face as an anode to a current in an electrolyte including hydroxide, carbonate and tungstate compounds of the alkali metals.

(3751) U. S. 1,958,357 (1934). J. A. Weiger (P. R. Mallory & Co., Inc.), *Make-and-Break Contact.* The method of manufacture comprises mixing together an oxide of W with a water-soluble alkali metal silicate, heat treating the mixture to convert the silicate to an oxide of Si and to reduce the WO_3 to W, heat treating to a temperature between 88 and 95% of the melting point of W, and mechanical working and heat treating.

(3752) U. S. 1,984,203 (1934). G. N. Sieger (P. R. Mallory & Co., Inc.), *Hard Metallic Contact.* A hard metallic contact is produced by forming a porous mass of 20-70% Ag and WC or Mo_2C and sintering; then incorporating into the pores a binding constituent of Ag.

(3753) Austrian 140,975 (1935). N. V. Molybdenum Co. and P. Schwarzkopf, *Material Consisting of Two Different Metals.* Powdered Mo, W, or Ta is mixed with Ag, Au, Al, Cu, Sn, or Zn and if necessary with Zr, Ti, Co, Fe, or Ni, and the mixture then compacted and sintered above the melting point of the lower melting constituent; the material is claimed useful for contact purposes.

(3754) Brit. 427,719 (1935). N. V. Molybdenum Co. and P. Schwarzkopf, *Composite Structural Material for Electrical Purposes.* The composite consists of two intimately united sheets; one contains W, Mo or Ta, while the other contains Ag, Al, Co, Ni or Cu. The high melting metal is present in ductile form, and is derived from sintered or molten bodies of the metal.

(3755) German 622,522 (1935). Metallwerk Plansee, G.m.b.H. and P. Schwarzkopf, *Metal Carbides for Electric Contacts.* The contacts consist of TiC as a single carbide, or mixed with other carbides; they are sintered, and then immersed in a lower melting metal.

(3756) Swiss 175,725 (1935). N. V. Molybdenum Co. and P. Schwarzkopf, *Compound Metal Body.* The body to be used as contact material consists of a higher melting metal, such as W, Mo, Ta and a lower melting metal, such as Cu or Ag; the powdered materials are sintered together.

(3757) Brit. 444,445 (1936). Siemens & Halske A. G., *Production of Electrical Contacts.* The contacts are manufactured by filling the pores of a body, formed by sintering a powder fusible only with difficulty, with a good conducting and easily fusible metal, and providing a gap between the mold and the surface of the body, to produce a coating of the conducting material.

(3758) Swiss 181,867 (1936). V. Sauter, *Metal Body for Electrical Purposes.* The body consists of 70% of a metal of periodic groups 1-6, *e.g.* (Cu, Ag, Au) and 30% of at least two metals of groups 4-8 (*e.g.* W, Mo) which are sintered by alternating current.

(3759) Swiss 184,392 (1936). Siemens & Halske A. G., *Production of Contact Bodies.* The pores of a sintered refractory metal powder body are filled with a lower melting metal in a form having a gap between the wall and the surface of the body, which is filled during the impregnation with the same lower melting metal having good conductivity.

(3760) U. S. 2,030,229 (1936). P. Schwarzkopf, *Agglomerated Structural Materials and Shaped Articles for Electrical Purposes.* Agglomerated structural materials are produced from refractory plus lower-melting metal powders by pouring the liquid soft metal over a compact of hard metal powders and then shaping and sintering the mixture.

(3761) U. S. 2,034,550 (1936). R. L. Adams (General Electric Co.), *Arcing Tips and Method of Making Same.* The method comprises pressing powdered W into a U-shaped member, impregnating with Cu and applying molten Cu to said impregnated member to provide a support.

(3762) U. S. 2,056,919 (1936). L. Casper (Western Electric Co.), *Electric Contact.* An electric contact is produced from finely divided WC and Co and is pressed and sintered.

(3763) Austrian 148,456 (1937). N. V. Molybdenum Co. and P. Schwarzkopf, *Material Consisting of Two Different Metals.* Addition to Aust. 140,975 (No. 3753). One of two closely joined layers is a sheet of W, Mo or Ta, the other consists of Ag or Cu.

(3764) Brit. 472,333 (1937). Patent Treuhandgesellschaft für Elektrische Glühlampen G. m. b. H., *Electrode Materials.* The electrodes consist of W and an alkaline earth compound (*e.g.* CaO, BaO); the constituents are powdered, mixed with binder, premolded into a paste and presintered, pressed and then sintered.

(3765) German 651,594 (1937). Deutsche Glühfadenfabrik Rich. Kurtz and P. Schwarzkopf, *Electric Contact.* The body is produced from sintered borides of metals of the 4th, 5th and 6th groups of the periodic system.

(3766) German 666,867 (1938). Stahlwerke Röchling-Buderus A. G., *Electrical Resistance Body.* Addition to German 469,433 (No. 3740). The modification comprises using a tempered binary alloy as binder for TaC.

(3767) Brit. 501,379 (1939). Compound Electro Metal Ltd. and F. R. Simms, *Metals for Contacts.* Electrical contacts consist of a thin surface layer of precious metals or alloys and a supporting body of a refractory metal mixed with a more fusible metal.

(3768) Brit. 513,623 (1939). Mallory Metallurgical Products Ltd., *Hard Alloy for Electrical Purposes.* A refractory material containing W or WC is formed into a porous mass and infiltrated with an age-hardening alloy which comprises highly conductive metals, such as Ag or Cu combined with Ni or Si.

(3769) German 681,403 (1939). Deutsche Edelstahlwerke A. G., *Formed Bodies from Refractory Metals, such as Contacts.* A method of producing formed bodies from refractory metals entails sintering and then working (hammering or drawing), followed by pulverizing the body, mixing the grains with low melting metal powders and pressing and sintering the mixture.

(3770) U. S. 2,154,288 (1939). P. Scholz (Siemens & Halske A. G.), *Electric Contacts.* The contacts are produced from powdered W, Mo, or Ta plus a lower melting-point metal. The refractory metal is sintered, impregnated with the lower melting metal, treated with HNO_3, whereby the lower melting metal is removed from the surface.

(3771) U. S. 2,162,380 (1939). A. S. Doty and E. F. Swazy (P. R. Mallory & Co. Inc.), *Refractory Metal Compositions Suitable for Electrical Contacts.* The bodies consist of Mo- and W-, and/or other carbides in a proportion of 30-90% and 10-20% Ag, and 0.1-2.5% Cu.

(3772) U. S. 2,165,481 (1939). K. L. Emmert and F. R. Hensel (P. R. Mallory & Co. Inc.), *Electrical Make-and-Break Contacts.* Ag plus 0.005-25% Th is claimed to reduce material transfer tendencies.

(3773) U. S. 2,179,960 (1939). P. Schwarzkopf (American Electro Metal Corp.), *Agglomerated Material in Particular for Electrical Purposes and Shaped Bodies Therefrom.* The bodies consist of at least one metal from the group W, Mo or Ta plus at least one metal from the group Ag, Ni, Co, Fe, Cu, Al, Au, Cr, Sn, Zn or Pt.

(3774) U. S. 2,180,826 (1939). F. R. Hensel and E. F. Swazy (P. R. Mallory & Co. Inc.), *Electric Contact.* The contact consists of 0.05-5% Si, 10-75% of a refractory material, and the balance Ag. The composition is free of Cu.

(3775) U. S. 2,180,956; 2,180,984 (1939). F. R. Hensel (P. R. Mallory & Co. Inc.), *Electric Contacting Elements, and Metal Composition for Them.* The composition consists of 50-99% of one of nitrides of Ti, Zr, Hf, V, Cb and Ta plus 1-50% Ag, Cu or Au and alloys consisting of these metals. An alternate composition range is 25-75% of nitrides of Ti, Zr, Hf, V, Cb, or Ta, plus up to 50% of a refractory material such as W and Mo or their carbides, with the remainder consisting of Cu, Ag or Au.

(3776) German 689,372 (1940). Siemens & Halske A.G., *Production of Electrical Contacts.* A sintered porous bar of refractory metal is put into a mold so that a gap is formed between one side of the bar and the mold, which then is filled with a low melting metal to form a coating on one side of the bar which is suitable for soldering.

(3777) U. S. 2,189,755 (1940). F. R. Hensel (P. R. Mallory & Co. Inc.), *Metal Composition.* An electric contact metal is formed of W particles bonded by an alloy of a lower melting-point containing 40-70% W, .5-5% of Cd, Zn, balance Ag.

(3778) U. S. 2,190,477 (1940). F. R. Hensel (P. R. Mallory & Co. Inc.), *Refractory Carbide Composition.* An electric contacting member comprises 1-50% ZrC, with the balance Ag, compacted into a solid mass.

(3779) U. S. 2,197,376 (1940). K. L. Emmert and J. W. Wiggs (P. R. Mallory & Co. Inc.), *Refractory Metal Composition for Contacts.* An electrical contact material consists of 10-40% Ni, 1-40% W, Mo, balance all Ag.

(3780) U. S. 2,200,087; 2,200,088 (1940). J. M. Kelly (Westinghouse Electric & Mfg. Co.), *Electrical Contacts.* The contacts consist of 45-75% powdered refractory metal impregnated with 25-55% of an alloy containing 90-98% Ag and 2-10% Cu, or Cu plus 0.5-5% Fe or Co; the product is quenched at 700° C. (1290° F.) and aged at 300° C. (570° F.).

(3781) U. S. 2,213,343 (1940). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co., Inc.), *Electric Contact Combination.* A contact combination in which the contact for the positive side is made of W and the contact for the negative side is formed from an alloy of W and Mo is used for D.C. automotive ignition circuits.

(3782) Brit. 532,447 (1941). Westinghouse Electric International Co., *Electrical Contact.* The contact contains 55-80% of a porous refractory metal from powders, comprising W, Mo or Ta, and impregnated and integrally united with 20-45% of an alloy composed of 0.5-3% Co and 0.5-3% Fe with the balance consisting of Cu.

(3783) Brit. 537,866 (1941). Mallory Metallurgical Products Co., *Electric Contacts.* An electrical contact is composed of W bonded with Ag and Ni; an example is 1-40% W, 10-40% Ni, balance Ag.

(3784) Brit. 540,360 (1941). Mallory Metallurgical Products Co., *Electrical Contacts.* The composition consists of 35-70% of a refractory metal carbide, 0.25%-15% Co and 25-64% Ag and 1% resin to facilitate the pressing.

(3785) U. S. 2,227,446 (1941). F. H. Driggs and W. H. Lenz (Fansteel Metallurgical Corp.), *Contact Alloys.* An electrical make-and-break contact consists of 99.50-99.98% W and 0.50 to 0.02% Ni, which is produced by sintering.

(3786) U. S. 2,234,834 (1941). H. Scott (Westinghouse Electric & Mfg. Co.), *Electrical Contact.* The contact comprises a laminated body of alternate layers of a good conducting metal and layers of a refractory metal from the W- and Mo-groups.

(3787) U. S. 2,234,969 (1941). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co. Inc.), *Tungsten-Base Contact.* The contact consists of a combination of two electrical contacting elements working against each other, one being a refractory boride, the other substantially pure W.

(3788) U. S. 2,250,099 (1941). F. R. Hensel (P. R. Mallory & Co. Inc.), *Antifriction Contact Material for Electrical Apparatus.* The material consists of 40-70% particles of Mo or W, 0.1-10% Fe, Co or Ni, plus a binder.

(3789) Swiss 219,210 (1942). G. Rau, *Production of Composite Metal Bodies.* Metal powders of W, Ag, and Cu are mixed, pressed to shape and sintered into contact material.

(3790) U. S. 2,298,999; 2,299,000 (1942). W. T. Allen (Square-D Co.), *Electrical Contact.* An electrical contact, having an Ag-W or Ag-Mo base is formed from powders and pressed.

(3791) U. S. 2,300,558 (1942). F. H. Driggs (Fansteel Metallurgical Corp.), *Electrical Contact.* An electrical contact is manufactured from compressed and sintered W or Si powder with WC.

(3792) U. S. 2,306,263 (1942). J. Gutbrod, K. Matthies and P. Scholz (Westinghouse Electric & Mfg. Co.), *Contact Pins.* The contact material is composed of

refractory metal powders sintered in a mold and impregnated with a highly conductive metal.

(3793) German 733,864 (1943). Deutsche Edelstahlwerke A. G., J. Gutbrod and B. Heinermann, *Electrical Contacts.* W- or Mo- powder is mixed with 1-15% monazite and heated at 900-1400° C. (1650-2550° F.) in a rare gas.

(3794) German 737,713 (1943). Siemens & Halske A. G. and P. Scholz, *Electrical Contact.* The contact is composed of a sintered porous body of refractory metal powder, and impregnated with Cu; after working, the composite is subjected to HNO_3 attack to remove Cu from the contacting surface.

(3795) U. S. 2,313,070 (1943). F. R. Hensel, E. I. Larsen and E. F. Swazy (P. R. Mallory & Co. Inc.), *Electrical Contacts.* Electrical contacts, suitable for withstanding severe loads, are made from a refractory metal, such as Ti, Zr, V, Cb, Ta, Mo, or W, in a proportion of 35-70% together with 0.25%-15% Co and 25-64% Ag.

(3796) U. S. 2,370,242 (1945). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Refractory Metal Composition.* An electrical contact composition contains W plus Mo particles coated with precious metal, *e.g.* Pt, Pd, Rh, Ag, Au, and Cu as additional element.

(3797) U. S. 2,387,614 (1945). R. H. Savage (General Electric Co.), *Electrical Contact Element.* A mixture of carbonaceous material, and finely divided metal and B_4C is pressed and fired.

(3798) U. S. 2,390,595 (1945). E. I. Larsen, V. E. Heil, and E. F. Swazy (P. R. Mallory & Co. Inc.), *Electrical Contact.* The contact composition comprises a mixture of a refractory constituent and a more fusible metal constituent; the contact face is substantially free of the more fusible metal constituent, being formed of the refractory constituent of the same microstructure as exists throughout the rest of the contact.

(3799) Brit. 578,430 (1946). Mallory Metallurgical Products Co. and F. R. Hensel, *Sparking Plug Electrodes.* Insulated W base sparking plug electrodes for aero-engines for high altitude use are made from a composite of W metal or alloy powders with 80-90% W and the rest borides or nitrides of metals of the 4, 5, or 6th groups of the periodic system.

(3800) Brit. 583,067 (1946). Mallory Metallurgical Products Co., *Electrical Contacts.* A facing layer of a WC-Co-Ag mixture is bonded to a metal backing of high thermal expansion material. The thermal stresses are taken up by an interposed layer of a low thermal expansion material.

(3801) Brit. Appl. 32,900/46 (1946). Soc. d'Électro Chimie, d'Électro Metallurgie et des Acieries Électriques d'Ugine, *Production of Metallic Agglomerates for Contacts.* Contacts of W-Cu, W-Ag, Mo-Cu, or Mo-Ag are made from powders containing the two metals and are prepared by chemical co-precipitation; the particles have an average size of 0.1-0.2 μ.

(3802) U. S. 2,409,664 (1946). D. G. Clifford (Westinghouse Electric & Mfg. Co.), *Electrode.* Crushed W is used for the electrode support of an electron discharge device.

(3803) U. S. 2,410,717 (1946). L. W. Cox (Cutler Hammer Inc.), *Electrical Contact Alloy.* A contact alloy of Mo and Ag is prepared by mixing their respective salts which then are filtered, washed, dried and reduced in H_2; the powder is then molded and the product annealed. The resulting alloy has a Rockwell B hardness of 75 which is increased to 97 by aging for several hours at 315° C. (600° F.).

(3804) Brit. 588,074 (1947). Mallory Metallurgical Products Co., *Sparkling Plugs.* Resistance to corrosion under heavy-duty conditions is improved by providing a Mo core with a sheathed tip of a Pt-base alloy, applied by swaging or electrodeposition.

(3805) Brit. 589,774 (1947). Mallory Metallurgical Products Co., E. I. Larsen and E. F. Swazy, *Composite Metal Articles for Use as Contacts.* A self-brazing backing for W parts sensitive to distortion is made by ball-milling a composition of 94% W and 3% each of Mo and Ni with 1% Glyptal.

(3806) U. S. 2,431,334 (1947). G. W. Lambert (Federal Telephone & Radio Corp.), *Electrical Contact.* Spot-welding electrodes free of sticking tendency consist of a W rod provided with a WC tip.

(3807) Brit. 608,124 (1948). General Electric Co. Ltd., *Metal Bodies for Electric Purposes.* W-Cu or W-Ag compacts for contacts or welding electrodes are made by reducing loosely packed WO_3 mixed with 3-4% Ni, sintering the porous body and impregnating with Cu or Ag.

(3808) U. S. 2,439,570 (1948). F. R. Hensel, E. I. Larsen and E. F. Swazy (P. R. Mallory & Co. Inc.), *Electrical Contact.* An electrical contact, suitable for operation under strong vibrations, is formed of 85-95% of refractory metal carbides, 2-10% Co, and 0.5-5% Ag.

(3809) Austrian 164,423 (1949). Metallwerk Plansee G.m.b.H., *Contact Material for Electrical Purposes.* The contact is manufactured from powders of Cu or Ag mixed with B-carbide or -nitride.

(3810) Brit. 621,471 (1949). The British Thomson-Houston Co. Ltd., *Electrical Contact Elements.* Minus 600 mesh B_4C is used as binder, either with graphite alone or with a graphite-metal powder mixture.

(3811) Brit. 626,483 (1949). Igranic Electric Co. Ltd., *Silver Base Non-Welding Electrical Contacts.* The initial contact resistance of Mo-Ag contacts is reduced to a minimum by applying to the pressing an Ag coating before sintering; Ag-Cd contacts are treated similarly.

ii. Other Composites

(3812) German 182,445 (1907). Gebr. Siemens & Co., *Electrical Contacts.* The contacts are produced from metal powders (*e.g.* Cu or Ag) mixed with graphite, pressed and formed in inert gases at elevated temperatures.

(3813) Swiss 102,403 (1923). Maschinenfabrik Oerlikon A. G., *Contact for Circuit Breakers.* One surface of the contact consists of a conducting oxide, *e.g.* Fe_2O_3, the other of an unalloyed conductor, *e. g.* Ag or Cr.

(3814) U. S. 1,685,919 (1928). E. Kramer (Hartstoff Metall A. G.), *Trolley.* A sliding contact for trolleys consists of a porous body made from fine metal powder, *e.g.*, Al mixed with 10-25% graphite powder.

(3815) U. S. 1,802,718 (1931). O. S. Jennings (Westinghouse Electric & Mfg. Co.), *Circuit-Breaker Contact.* The circuit breaker comprises a conglomerate contact of metals having a low melting point and an anti-flux binder, *e.g.* Ag-graphite and a contact of a metal of higher melting point, *e.g.* Ni.

(3816) Brit. 437,713 (1935). British Thomson-Houston Co. Ltd., *Contact Point Alloy.* Ag, PbO_2 or Pb (5-20%) with or without W and/or Mo powders are mixed, pressed and sintered at 700-900° C. (1290-1650° F.).

(3817) German 610,260 (1935). Siemens-Schuckertwerke A. G., *Contact for Switches.* The contact is composed of two parts; one consists of a mixture of Ag and graphite, the other of Cu and graphite, whereby the Ag part forms the surface of the contact.

(3818) Austrian 146,938 (1936). Allgemeine Elektrizitäts Gesellschaft, *Alloy for Electrical Contacts.* Ag is mixed with 1-20% Pb or PbO_2 and, if necessary, some amount of Mo or W, then formed and sintered.

(3819) U. S. S. R. 51,574 (1937). T. A. Gonionskii, *Electrical Contacts from Silver and Silver-Copper.* The contacts are manufactured from Ag precipitated from diluted $AgNO_3$ by Cu powder, and combined with carbonaceous material.

(3820) U. S. 2,137,617 (1938). H. F. Fruth and R. H. Imes (P. R. Mallory & Co.), *Electrical Contacts.* The contacts are formed from different metals, *e.g.* Ag, on a steel backing.

(3821) U. S. 2,145,690 (1939). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Electric Contact Material.* The composition of 50% or less CdO, Cu or Ag, and up to 20% graphite, avoids sticking and fusing of the contact.

(3822) U. S. 2,154,700 (1939). S. Ruben, *Electric Contacts.* The contacts contain Cr plus 1-10% Sn and possess workability.

(3823) U. S. 2,165,029 (1939). L. T. Bourland (Westinghouse Electric & Mfg. Co.), *External Contact for Copper Oxide Rectifiers.* The contact is composed of a layer of CuO and a contact layer of a mixture of 50-85% Sn and 15-50% Pb and sintered.

(3824) Swed. 98,833 (1940). J. F. Heuberger, *Pressed and Sintered Metal Articles.* Electric contacts are manufactured from Cu and non-metallic powders, also small quantities of S, Se, or Te are added.

(3825) U. S. 2,188,873 (1940). G. J. Comstock (Handy & Harman), *Making Articles from Powdered Components.* The constitution of the material comprises 93% Ag, and graphite in the interstices of a network of Ag; the powders are mixed, pressed, sintered, worked and heat-treated to form stock for drawing rod for electrical contact purposes.

(3826) U. S. 2,199,458 (1940). F. R. Hensel, K. L. Emmert, and J. W. Wiggs (P. R. Mallory and Co. Inc.), *Electric Contact.* The contact contains not less than 75% Ag and 0.2-5% Ca, Ba or Sr; Ni, Co, or Fe may be added. The powders are pressed and sintered.

(3827) U. S. 2,200,855 (1940). S. Ruben, *Electrical Contact.* Ag or Cu powders are mixed with 1-25% Sb_2O_3, pressed and sintered.

(3828) Brit. 534,407 (1941). P. R. Mallory & Co., *Silver Alloys.* Make-and-break contacts comprise an Ag-base alloy with additions of 0.05-15% Mg and 1-40% Ni.

(3829) German Appl. D. 84,704 (1941). E. Dürrwächter, *Malleable Sintered Bodies.* Contacts of fairly coarse Ag powder and colloidal graphite are made by pressing the mixture at 40-60 tsi and slow sintering in vacuum.

(3830) U. S. 2,249,599 (1941). R. M. Burns and E. M. Tolman (Bell Telephone Laboratories), *Electrical Contact.* The contact consists of a body of Ag and Cr powder dispersed throughout.

(3831) Canadian 441,396 (1942). Square-D Co., *Electrical Contact.* An Ag-Fe_2O_3 contact is made by mixing 15% Fe powder and 85% Fe_2O_3, pressing and sintering for 1 hr. at 980° C. (1800° F.) in CO_2.

(3832) U. S. 2,278,592 (1942). V. H. Sanders, N. J. Schaberl and E. I. Shobert II (Stackpole Carbon Co.), *Contact Element.* An electrical contact element is produced by cold molding a mixture of alloy-forming metal powders and a deoxidizing agent to the back of a layer of a powdered electrical contact face material containing 95% Ag and 5% graphite to form a powdered composite body, and then hot-molding and brazing the composite to a metal support. An example of the alloy is 69% Ag, 29% Cu, 2% P.

(3833) U. S. 2,288,122 (1942). I. W. Cox (Cutler-Hammer Inc.), *Electrical Contacts.* Contacts of Ag plus 20% CdS or less are molded under pressure without sintering.

(3834) U. S. 2,303,497 (1942). H. T. Reeve (Bell Telephone Laboratories), *Electrical Contact.* The contact consists of a composite of Pd-coated Ag with an underlying layer of Pd-Ag alloy.

(3835) French 883,115 (1943). E. Dürrwächter, *Material for Electrical Contacts.* The contacts are composed of a mixture of 95-99.9% rare metals plus colloidal graphite.

(3836) French 883,116 (1943). E. Dürrwächter, *Production of Circuit Breakers.* The material consists of electrographite mixed with metal powders, *e.g.* Ag, and formed into bars which are cut into small pieces.

(3837) French 883,334 (1943). Siemens Planiawerke A. G. für Kohlefabrikate, *Carbon Contact for Dynamos.* The C contact possesses an electrographite structure with a metal (*e.g.* Ag) or a metal alloy precipitated from solution into its pores.

(3838) U. S. 2,307,668 (1943). I. W. Cox (Cutler-Hammer Inc.), *Electrical Contact.* An electric switch contact consisting of 90% Ag powder of fibrous texture plus 10% CdO is cold molded at 40,000 psi, thereby being adapted for normal use without sintering.

(3839) U. S. 2,319,240 (1943). E. I. Larsen and E. F. Swazy (P. R. Mallory & Co. Inc.), *Electrical Contact.* A composite electric contact face plate comprises powdered contact material, such as Ag or Cu, sintered to a backing member.

(3840) Swiss 229,889 (1944). E. Dürrwächter, *Production of Shaped Sintered Bodies for Electrical Purposes.* The bodies are produced from a mixture of Ag powder with 0.1-10% colloidal graphite.

(3841) Swiss 229,890 (1944). E. Dürrwächter, *Material for Electrical Contacts.* The contacts consist of 75-99.9% precious metal powder mixed with 0.1-5% colloidal graphite.

(3842) U. S. 2,358,326 (1944). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Metal Composition.* A material used for electrical contacts is formed from metal particles, such as Ni and Co, coated with a metal, such as Pd, Pt or Rh, and a metal, such as Cu, Ag, or Au is interspersed with and bonded to the coated particles.

(3843) U. S. 2,360,522 (1944). E. I. Shobert and A. J. Schutz (Stackpole Carbon Co.), *Manufacture of Electric Contacts.* A method of making an electric contact element comprises pressing an intimate mixture of powdered contact metal and powdered CdO and baking the compact in an atmosphere of N_2 while exposing one face to reducing conditions and thereby reducing CdO at that surface.

(3844) U. S. 2,361,089 (1944). I. W. Cox (Cutler-Hammer Inc.), *Pressure Molded Metallic Composition Article and Support and Method of Making Same.* A combination of a contact-support sheet and a powdered metallic contact composition is manufactured by compression and mechanical interlocking of the contact layer and sheet without sintering.

(3845) U. S. 2,365,249 (1944). G. J. Comstock (Baker & Co. and American Platinum Works), *Electrical Contact Element.* The contact element is composed of powders of Ag and carbonyl-Fe and fabricated by pressing and sintering.

(3846) Brit. 574,076 (1945). Mallory Metallurgical Products Co., *Powder Metal Electrical Contacts.* Compositions suitable for production of articles, such as electrical contacts, consist of Ni or Co powders coated with a Pt-group metal mixed with Cu, Ag, or Au. When the powdered mixture is sintered, the Pt-metal diffuses into the Ni or Co and the alloy thus formed is resistant to oxidation.

(3847) U. S. 2,382,338 (1945). E. I. Shobert (Stackpole Carbon Co.), *Electric Contacts.* An Ag-CdO electric contact containing up to 20% of the oxide is pressed and then heated in oxidizing atmosphere while exposing a single face to reducing conditions to reduce the CdO to metallic Cd.

(3848) Brit. 576,155 (1946). British Thomson-Houston Co. Ltd., *Electrical Contact Elements.* The elements comprise a molded porous block of finely divided conducting material impregnated with a lubricant of a solution of polyhydric alcohol or alcohol-ether, such as glycerol.

(3849) Brit. 576,566 (1946). Mallory Metallurgical Products Co., *Electrical Contacts.* Electrical contacts are composed of at least 50% and preferably 90% of Cu, Ag, or Au with the remainder consisting of an oxide of Be, Mg, Ca, Sr, or Ba having a melting point exceeding 1000° C. (1800° F.).

(3850) Brit. 577,091 (1946). British Thomson-Houston Co. Ltd., *Electric Contact.* A contact for long wearing life is made from powders of 40% Cu, 40% Ca, and 20% ZnO.

(3851) Brit. 578,936 (1946). Baker & Co. and American Platinum Works, *Electrical Contacts.* Ag powder is mixed with 10-40% carbonyl Fe powder and is pressed at 12 tsi, sintered at 900° C. (1650° F.) for ½ hr. in H_2, cold rolled and annealed.

(3852) U. S. 2,393,816 (1946). R. H. Savage (General Electric Co.), *Electrical Contact Elements.* The contacts consist of porous blocks of electrically conductive material, *e.g.*, metal-graphite, impregnated with a mixture of ingredients including an alcohol-ether and a polyester, formed by the reaction of dihydric alcohol and an aromatic dicarboxylic acid.

(3853) U. S. 2,394,501 (1946). P. G. Weiller (Square D Co.), *Electrical Contact.* The contact is composed of a mixture of finely divided particles of Fe_2O_3 and a metal having a highly conductive oxide, such as Ag.

(3854) U. S. 2,396,101 (1946). F. R. Hensel (P. R. Mallory & Co. Inc.), *Electric Contact.* The contact is formed of a powdered refractory oxide and Ag or Cu.

(3855) Brit. 586,965 (1947). British Thomson-Houston Co. Ltd., *Electrical Contact Elements. Cf.:* U.S. 2,393,816 (No. 3852).

(3856) Brit. 587,173 (1947). Igranic Electric Co. Ltd., *Electric Contact Tips.* Ag flake powder, made by electrodeposition on stainless steel balls, is mixed with CdO and pressed into electric contact tips.

(3857) Brit. 588,652 (1947). Igranic Electric Co. Ltd., *Electrical Contact Material.* An electrical contact material is composed of Ag, CdO, and a metallic salt; the CdO being in smaller proportion than the Ag, and the metallic salt being in smaller proportion than the CdO.

(3858) Brit. 592,355 (1947). British Thomson-Houston Co. Ltd., *Electrical Contact.* The manufacture of the contact comprises mixing finely divided carbonaceous material with Cu and S, and pressing the mixture in a mold at 10-15 tsi in a reducing atmosphere at 700° C. (1290° F.).

(3859) Brit. 593,171 (1947). Igranic Electric Co., *Electrical Contacts.* Contact tips of Ag-CdO are riveted to their supports by compressing the slug in a die at 50 tsi.

(3860) Brit. Appl. 18815/47 (1947). Igranic Electric Co. Ltd., *Electric Contacts.* Ag-CdO contacts having a thin Ag backing for brazing are made by compacting a layer of Ag powder and a layer of mixed powders. After sintering, the strip is rolled hot and annealed at 650° C. (1200° F.) and rolled again. The Ag side is punched with gauze markings.

(3861) U. S. 2,416,830 (1947). J. F. Heuberger, *Iron Graphite Contact.* A sliding contact is produced by pressing a mixture of metal powders and graphite in the form of layers lying orientated in planes perpendicular to the wearing surface.

(3862) U. S. 2,418,811 (1947). R. L. Adams and L. Zickrick (General Electric Co.), *Electrical Contact.* The contact is made in form of a block by mixing graphite, finely divided Ag and Ag_2S or CuO and S, pressing the mixture in a mold and heating it at 650-700° C. (1200-1290° F.) in an atmosphere of H_2.

(3863) U. S. 2,418,710 (1947). F. R. Hensel (P. R. Mallory & Co. Inc.), *Electrical Contacts and Brushes.* Contacts consist of composite alloys of Pd and/or Pt, balance Pb.

(3864) U. S. 2,425,052 (1947). M. R. Swinehart (Cutler-Hammer Inc.), *Electric Contact.* The contact is formed of powders comprising 87% Ag, 11.86% CaO and 0.64% AgI; the product has constant contact resistance.

(3865) U. S. 2,425,053 (1947). M. R. Swinehart (Cutler-Hammer Inc.), *Silver-Backed Contact.* A body is composed of a non-welding Ag-base powder and a thin back portion composed of fine Ag powders of different types; its manufacture comprises sintering the body at 870° C. (1600° F.) to shrink all portions to corresponding degrees, then molding the preformed body at a high pressure with the fine Ag portion.

(3866) U. S. 2,425,919 (1947). I. W. Cox (Cutler-Hammer Inc.), *Molding Contact Tips.* Tips are rigidly attached to a metal support, without heating and sintering, incidental to the molding operation, by producing Ag flakes in the proper degree of fineness for molding under pressure.

(3867) U. S. 2,426,659 (1947). J. Wulff, *Producing Electrical Contact Material.* Stainless steel powder made by intercrystalline corrosion in accordance with U. S. 2,407,862 (No. 1317) and Ag powder are mixed; the stainless steel powder has a particle size distribution of 66% between 100-200 mesh, 17% 200-325 mesh, 17% below 325 mesh. The mixture is cold pressed and sintered below the melting point of Ag.

(3868) U. S. 2,431,474 (1947). A. Gaudenzi and E. Kern (Brown, Boveri & Co.), *Composite Insulating Bushing.* The bushing consists of a mixture of electrically conducting and non-conducting powders, pressed and sintered; the relative proportions of the components are graded within the article to provide conductivity progressively decreasing from the conducting surface portion to the insulating portion.

(3869) Brit. Appl. 25976/48 (1948). Handy & Harman, *Making Compacted Metal Contacts.* Ag-CdO contacts are made from powder that is prepared by precipitating the mixed hydrates from a mixed nitrate solution with caustic soda, and heating the

precipitate in air at 480° C. (896° F.); the powder is then pressed and sintered into contact shapes.

(3870) Canadian 453,518 (1948). P. R. Mallory & Co. Inc., F. R. Hensel and E. I. Larsen, *Metal Composition.* Contacts are made by pressing and sintering of Ni or Co particles coated with Pt or Rh; Cu, Ag or Au are interspersed with, and bonded to, the coated particles.

(3871) U. S. 2,444,348 (1948). R. I. Hahn (General Motors Corp.), *Electric Annealing Apparatus.* The apparatus involves using cylindrical rods of a non-abrasive conducting material, fabricated by sintering a mixture of 60% Cu and 40% graphite, to provide an improved electric connection between the material and the electrode boxes.

(3872) Brit. 596,686 (1948). Igranic Electric Co. Ltd. and M. R. Swinehart, *Electrical Contacts.* The contacts are made of a molded and sintered Ag composition (82% precipitated Ag, 15% CdO, 3% CdS), having a layer of fine Ag (80% precipitated and 20% crystalline Ag), molded integrally therewith, and forming the rear face, to provide for attachment to a metal support by welding.

(3873) Brit. 614,372 (1949). Igranic Electric Co. Ltd., *Electric Contact.* An improvement on Ag-CdO contacts described in Brit. 588,652 (No. 3857) consists of substituting densified In-oxide for CdO.

(3874) Brit. 614,598 (1949). Mallory Metallurgical Products Co. Ltd., *Composite Material for Bearings of Electrical Elements.* Bearings having good electrical conductivity for welding machines are made by sintering and coining pressings with alternate segments of Ag powder and a 95-5 Ag-graphite mix.

(3875) U. S. 2,468,888 (1949). H. L. Mekelburg (Cutler-Hammer, Inc.), *Metal-Backed Nonwelding Contact.* The composite comprises an active part of Ag-base non-welding material and a backing of fine Ag integrally united therewith; the fine Ag is in the form of a thin layer to provide for attachment of the contact to a metal support by welding or brazing. The contact is so shaped as to provide a receptacle between it and the support for all excess of fused silver or brazing material.

(3876) U. S. 2,486,341 (1949). M. J. Stumbock, (Baker & Co., Inc.), *Electrical Contact Element Containing Tin Oxide.* The contact is formed of a compressed and sintered metal powder taken from the group consisting of Ag and Cu, and SnO_2 (0.1 to 10% of the whole) distributed throughout.

(3877) U. S. 2,490,214 (1949). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Electrical Contacting Element.* Ag or Cu contacts are made with an addition of up to 10% of a carbonate of Ca or Ba; the sintering is effected at a temperature below the decomposition temperature of the carbonate.

iii. Refractory Metal Alloys

(3878) U. S. 1,877,261 (1932). J. A. Weiger (P. R. Mallory & Co. Inc.), *Electrical Make-and-Break Contact and Composition Thereof.* The contact is formed from an alloy of Rh and W by rolling or drawing into shape.

(3879) U. S. 2,094,570 (1937). P. H. Estes and F. H. Clark (The Western Union Telegraph Co.), *Electric Contact.* The contact consists of a mixture of W and Pt powder, whereby the boundaries of the W particles are composed of a solution of W-Pt; the cohesive union between all particles is provided only by said solution.

(3880) U. S. 2,143,375 (1939). C. B. Gwyn (P. R. Mallory & Co. Inc.), *Electric Make-and-Break Contacts.* Contact points are produced by making a mixture of a water-soluble alkali metal with WO_3 and MoO_3, pressing, heating, swaging to a rod, heat treating it at 2400-3200° C. (4350-5800° F.) and rolling to a sheet from which points are punched.

(3881) U. S. 2,163,354 (1939). J. F. Jack and A. C. Schmidt (H. A. Wilson Co.), *Electrical Make-and-Break Contacts.* 0.1-2.5% Os is mixed with W to produce a body of a single crystal and thus devoid of grain boundaries.

(3882) U. S. 2,187,378 (1940). F. R. Hensel (P. R. Mallory & Co. Inc.), *Abrasion Resistant Electric Contact.* The contact consists of an alloy containing 60% Pd, 20% Ag, 14% Au and 6% Co, and is produced from the powdered ingredients.

(3883) U. S. 2,197,380 (1940). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co. Inc.), *Electric Contact Element.* The contact contains 0.1-35% U, balance substantially all W.

(3884) German 707,861 (1941). Heraeus Vacuumschmelze A. G., M. Auswärter, K. Ruthardt and O. Winkler, *Electrical Contact.* The contact consists of a sintered alloy of 5-70% Pt, 25-90% Ag, remainder Ni or Co.

(3885) Italian 385,508 (1941). Robert Bosch G.m.b.H., *Material for Electric Contacts.* Electric contacts, especially useful for a large amount of contact breaking at high speed, are produced from a sintered mixture of W and Pt powders.

(3886) U. S. 2,227,445 (1941). F. H. Driggs and C. B. Gwyn, Jr. (Fansteel Metallurgical Co.), *Contact Alloy and Method of Making Same.* 96-99½% W, and 4-½% Ni are pressed and sintered at 1500° C. (2730° F.) in a non-oxidizing atmosphere to produce a dense body.

(3887) U. S. 2,247,755 (1941). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co. Inc.), *Electrical Contact.* The contact has a W or Mo body with a Rh facing which is applied in powdered form by spraying.

(3888) Swiss 227,432 (1943). Robert Bosch G.m.b.H., *Electrical Contact.* The contact-making parts are produced from mixed powders of W and Pt, which form an alloy upon sintering.

(3889) Brit. 575,998 (1946). A. B. Middleton, *Precious Metals and Alloys Thereof.* Material for use at high temperatures, *e. g.* spark-plug electrodes, is produced by sintering powdered precious metals, such as Pt, Pd, or Ru and containing other powdered metals, such as Ti, Zr, Ta, V, Mo, or W, producing a fibrous microstructure in the consolidated product.

(3890) Brit. 578,675 (1946). Mond Nickel Co. and E. C. Rhodes, *Sintered Powdered Metals for Spark Electrodes.* The composition consists of alloy powders of a Pt-group metal with or without other additions, *e. g.* W, made from specially prepared complex salts which on ignition are reduced to the metal.

(3891) Brit. 605,159 (1948). Rotax Ltd. and J. Levy, *Heat Treatment of Tungsten Contacts.* W contacts are toughened and made oxidation-resistant by heat treating in reducing atmosphere at 1500° C. (2730° F.) for 1 hour in the presence of V_2O_5, which is reduced to V and alloys with the W.

iv. Low-Melting Metal Alloys (Copper or Silver-Base)

(3892) U. S. 842,730 (1907). H. Viertel and G. Egly (Gebr. Siemens & Co.), *Method of Making Electrically Conducting Bodies for Use as Contacts.* Contact material of Cu, Sn, Zn, is molded and heated in H_2 atmosphere until alloyed.

(3893) U. S. 1,648,100 (1927). E. Aichele, *Composition of Matter.* A semi-plastic, non-fusible metallic composition suitable for electric contacts comprises 1 part Pb, 1 part acid-cleaned Cu powder, and 1 part Hg by weight.

(3894) U. S. 1,940,962 (1933). L. H. Matthias (Allen-Bradley Co.), *Contact For Electrical Circuit Breaker Mechanisms.* The contact is composed of Ag-Cd alloy, with Ag predominating.

(3895) French 792,568 (1936). N. V. Molybdenum Co., *Material for Electrical Contacts.* The contacts consist of Cu with 1-10% Cd or Cd alloy, and contain 0.1-5% Mg, Al or Be, and Ag.

(3896) German 637,547 (1936). Allgemeine Elektrizitäts Gesellschaft, *Electrode.* An electrode which is resistant to compression and is wear-resistant, consists of 97% Cu, 1% Be, and 2% Co, and is manufactured from powders, which are pressed and sintered.

(3897) Austrian 150,282 (1937). N. V. Molybdenum Co., *Contact Material.* The material consists of an alloy of Cu, Ag or Au with 0.1-10% Cd.

(3898) U. S. 2,086,604 (1937). G. F. Comstock (Titanium Alloy Manufacturing Co.), *Copper-Titanium-Silicon Alloy for Electrical Conductor.* A heat-hardened Cu-Ti-Si alloy contains less than 1½% Ti and still less Si, with the balance being Cu.

(3899) Austrian 154,352 (1938). N. V. Molybdenum Co., *Contact Material.* Addition to Austrian 150,282 (No. 3897). 0.1-5% B is added to the alloy.

(3900) U. S. 2,116,252 (1938). H. H. Schwarzkopf (N. V. Molybdenum Co.), *Alloys for Electrical Contacts and Electrodes.* A sintered or cast Cu-Cd-B surface layer which is subjected to arcing is produced on contacts and electrodes.

(3901) U. S. 2,119,965 (1938). H. H. Schwarzkopf (N. V. Molybdenum Co.), *Electrical Contact Alloy.* A sintered or cast electrical contact alloy consists of Cu-Cd-Ag or Au, and contains deoxidizers, such as Al, Mg, or Be; it can also be used together with up to 80% carbides.

(3902) U. S. 2,135,336 (1938). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Copper Alloys Suitable for Electrical Contacts.* The alloys consist of Cu plus 1-10% Co, 0.05-5% Si, and 0.05-2.5% Be.

(3903) U. S. 2,136,915 (1938). K. L. Emmert (P. R. Mallory & Co. Inc.), *Silver Alloys Suitable for Electric Contacts.* The material consists of Ag plus .1-5.0% Ni, 0.5-25% Cd, and 5-35% Cu. The alloys show less tendency to oxidize or form sulfides than plain Ag-Cu alloys.

(3904) U. S. 2,137,281 (1938). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Copper Alloys Sintered for Electrical Contacts.* Age hardened alloys of Cu, with up to 3% Zr, and up to 5% Fe, Co or Ni, have high hardness and high conductivity; these properties are not affected permanently by temperatures in the order of 450° C. (840° F.).

(3905) U. S. 2,138,599 (1938). C. B. Gwyn (P. R. Mallory & Co. Inc.), *Alloys for Electric Contacts.* The alloys consist of 5-15% Cu, 7% Ni, 12-25% Pd or Pt, and 50-80% Ag.

(3906) U. S. 2,141,113 (1938). C. Peterson (H. A. Wilson Co.), *Contact.* A contact for electrical circuit breaker mechanisms is composed of an Ag-Mn alloy.

(3907) Brit. 500,930 (1939). Vereinigte Aluminiumwerke A. G., *Electric Contacts.* An electric contact of Al becomes uniform in resistance when an oxide film is produced on its particles by chemical or electrolytic means.

(3908) Brit. 505,017 (1939). N. V. Molybdenum Co., *Electric Contacts.* The contacts consist of Cu, 0.1-10% Cd, 0.1-5% Cr, 0.1-5% Fe, Co or Ni and other elements in minor proportion; the ingredients are powdered, pressed and sintered.

(3909) U. S. 2,143,915 (1939). E. I. Larsen and F. R. Hensel (P. R. Mallory & Co. Inc.), *Copper-Silver-Beryllium-Nickel Alloys.* Alloys for use as electrical contact materials consist of Cu plus 0.05-3% Be, 0.05-4% Ag, and 0.05-10% Ni.

(3910) U. S. 2,145,792 (1939). E. I. Larsen and F. R. Hensel (P. R. Mallory & Co. Inc.), *Electric Contacts.* The material consists of a Cu alloy with 0.1-10% each of Co and Cd; the contacts excel by their durability.

(3911) U. S. 2,148,562 (1939). H. T. Reeve and E. F. Kingsbury (Bell Telephone Co.), *Palladium-Copper Alloys for Electrical Contacts.* An alloy consisting of 50.7-62.7% Pd and 49.3-37.3% Cu is heated in H_2.

(3912) U. S. 2,151,905 (1939). K. L. Emmert (P. R. Mallory & Co. Inc.), *Make-and-Break Contacts for Direct Current Operation.* The plus contact consists of an Ag alloy with Cd, and the minus contact of Ag plus Cu, Pd or Pt.

(3913) U. S. 2,154,068 (1939). W. C. Ellis (Bell Telephone Co.), *Alloys for Electrical Contacts, Such as Those of Telephone Switches.* The alloys contain 90-99% Ag and 1-10% Sn.

(3914) U. S. 2,156,974 (1939). G. E. Doan, *Non-Arcing Circuit Breaker.* The breaker consists of an electrode of Fe which is 99.3% pure.

(3915) U. S. 2,159,763 (1939). F. R. Hensel (P. R. Mallory & Co. Inc.), *Nickel-Cadmium-Silver Alloys for Electrical Contacts.* The alloys consist of Ag plus 25-90% Ni or Co and 1-30% Cd or Zn.

(3916) U. S. 2,161,253; 2,161,254 (1939). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co. Inc.), *Silver-Base Electrical Contact.* An Ag-base electrical contact for severe service consists of an alloy of Ag plus 0.05-20% Mg.

(3917) U. S. 2,161,574; 2,161,575; 2,161,576 (1939). F. R. Hensel, K. L. Emmert and J. W. Wiggs (P. R. Mallory & Co. Inc.), *Silver Alloys Suitable for Make-and-Break Contacts.* Typical alloy compositions are (*1*) Ag plus 0.05-15% Mg, 0.05-25% Au; (2) Ag plus 0.1-15% Mg, 0.5-25% Cd; and (*3*) Ag plus 0.05-15% Mg, 0.005-10% Th.

(3918) U. S. 2,166,248 (1939). F. R. Hensel and K. L. Emmert (P. R. Mallory & Co. Inc.), *Electric Contacts of Silver Alloys.* The alloys consist of Ag plus 1% W or Mo, 0.1-30% Mn, and may also include other metals.

(3919) U. S. 2,170,431 (1939). H. H. Schwarzkopf (N. V. Molybdenum Co.), *Alloy for Electric Contacts.* The alloy consists of 94.7% Cu, 4% Ag, 1% Cd, and 0.3% B.

(3920) Austrian 158,544 (1940). Deutsche Edelstahlwerke A. G., *Material for Electric Contacts.* The alloy consists of 3% Cr, 1.5% Fe, 1% Cd, remainder Cu.

(3921) U. S. 2,187,377 (1940). F. R. Hensel (P. R. Mallory & Co. Inc.), *Wear Resistant Electric Contact.* The wear resistance of a contact is improved by using an Ag-base sintered alloy wherein is distributed a sub-microscopic precipitated phase of Cu.

(3922) U. S. 2,218,073 (1940). H. H. Schwarzkopf and R. Kieffer (American Electro Metal Corp.), *Alloy for Electric Purposes.* The alloy consists of 0.1-10% Cd, 0.1-5% Cr, 0.1-5% Fe or Ni, balance Ag, Au and Cu; a minimum of 79% Cu must be present.

(3923) Brit. 540,958 (1941). Mallory Metallurgical Products Co. Ltd., *Electrical Contact Elements.* The contacts have a Cu-base and contain 0.25-5% Cd and 0.05-3% Te.

(3924) Canadian 435,488 (1941). I. T. E. Circuit Breaker Co. and H. C. Graves, Jr., *Contact Material. Cf.:* U. S. 2,370,400 (No. 3929).

(3925) U. S. 2,241,262 (1941). C. W. Keitel (Baker & Co.), *Electrical Contact.* The contact contains Ag plus Ru in a proportion of 0.1 to 95%; Pd, Rh, Os, or Ir may replace Ru fully or in part.

(3926) U. S. 2,258,492 (1941). F. R. Hensel, J. W. Wiggs and K. L. Emmert (P. R. Mallory & Co. Inc.), *Electric Contacts Suitable for Make-and-Break Contacts.* The contact alloy contains 0.1-10% Al, 0.1-25% Cd, balance Ag.

(3927) German 742,018 (1943). Siemens-Schuckertwerke A. G., K. Rube and E. Stohl, *Metal Parts for Electrochemical Work.* A contact metal, such as Cu, is coated on a light metal part and pressed into the piece.

(3928) U. S. 2,347,172 (1944). I. W. Cox (Cutler-Hammer Inc.), *Electrical Contact Tip.* An electrical contact tip is molded from Ag powder.

(3929) U. S. 2,370,400 (1945). H. C. Graves, Jr. (I. T. E. Circuit Breaker Co.), *Contact Materials.* An electrical contact having a surface for engaging a second contact comprises finely divided Cu and a lower melting metal, such as Cd; the mixture is compressed and sintered.

(3930) U. S. 2,379,232 (1945). F. R. Hensel (P. R. Mallory & Co. Inc.), *Sintered Copper-Silver Composition Containing Bismuth.* A sintered component of Cu, Ag and 5-60% Bi is used for an operative element of an electric control system.

(3931) U. S. 2,396,100 (1946). F. R. Hensel (P. R. Mallory & Co. Inc.), *Electric Contact.* An electric contact is formed of an Ag-base alloy containing Pb or Tl powders.

(3932) U. S. 2,396,977 (1946). E. G. Widell (Radio Corp. of America), *Electrode Alloys.* A drawn wire electrode for radio tubes consists of 1-2% Al, 0.66-3% W, 0.5-5% C, balance Ni.

(3933) Brit. Appl. 27745/47 (1947). Igranic Electric Co. Ltd., *Electric Contact.* Ag shot of 1/8 in. diameter is pressed between cold welding electrodes into contact tips, which are welded to a support.

(3934) Austrian 162,573 (1949). Metallwerk Plansee G.m.b.H., *Contact Material.* The material consists of 10% Ag, 3% Ni, Cd, Co, or Cr, 0.5-5% oxide of Al or Cr, and remainder Cu.

B. Current Collector Brushes, Commutators, Rotors

(3935) Swedish 25,103 (1908). Rylander & Rudolphs Fabriks A. B., *Composition of Graphite with Metals.* The material is composed of 30-80% Cu, and 2-20% Sn powder mixed with 5-20% graphite and 1-1.5% Hg; the powders are pressed and annealed, to remove Hg. Material is useful for electrical products.

(3936) U. S. 1,067,003 (1913). W. Deats and C. Scott (National Carbon Co.), *Method of Making Electrical Conductors.* Finely pulverized C and metallic Cu are mixed together and baked, to form conductors, brushes and the like.

(3937) U. S. 1,093,614 (1914). E. G. Gilson (General Electric Co.), *Brush For Dynamo-Electric Machines.* The mixture is composed of Cu_2O, graphite, and heated for a sufficient time so that a large part of the metal components will have been reduced, but the reaction is stopped before complete reduction has taken place; Fe_2O_3 is added and the mixture is molded and sintered to complete the reduction and effect alloying of the ingredients.

(3938) U. S. 1,375,879 (1921). H. H. Wikle, *Collector Brushes.* Collector brushes are manufactured by bonding by pressure a mixture of finely divided Cu and graphite.

(3939) German 349,681 (1922). L. Boudreaux, *Brushes for Electrical Motors.* The brushes consist of a porous metallic core whose pores are filled with a lower melting metal.

(3940) U. S. 1,728,273 (1929). E. J. Hall (Metals Disintegrating Co.), *Machine for Making Commutator Brushes and the Like.* Cu powder is pressed in a mold around a lead wire.

(3941) French 741,753 (1932). S. A. Le Carbone-Lorraine, *Graphite Brushes.* For the production of the brushes graphite is mixed with Cu powder whose particles are coated with Ag.

(3942) U. S. 1,878,132 (1932). E. J. Hall (Metals Disintegrating Co.), *Process of Baking Molded Pieces.* Commutator brush manufacture consists of molding the brush around a pigtail wire.

(3943) Brit. 392,067 (1933). Comp. Lorraine De Charbons Pour L'Électricité, *Securing a Conductor to a Carbon Brush.* The process comprises inserting the conductor into a hollow portion in the brush, packing in a conductive powder and heating to agglomerate.

(3944) U. S. 2,033,709; 2,033,710 (1936). F. R. Hensel and E. I. Larsen, (Westinghouse Electric & Mfg. Co.), *Commutator Segments.* Commutator segments or collector rings are produced from a powdered mixture of 0.01-5% Ag, 0.05-5% Cr, and balance Cu; the powders are pressed and sintered.

(3945) U. S. 2,053,662 (1936). C. Hardy (Hardy Metallurgical Co.), *Method of Making Electrical Conductors.* Electrical conductors such as commutator segments are produced by compressing metal powders in the cold state to form hard commutator segments, incorporating them into the commutator and then subjecting the composed article to sintering.

(3946) French 883,114 (1943). E. Dürrwächter, *Collector for Electrical Machines.* The laminae of the collector are composed of several layers of graphite-Ag mixtures, of which one contains 80% Ag and the next 40% Ag.

(3947) German 735,871 (1943). Robert Bosch G.m.b.H. and E. Durst, *Commutator of Porous Metal.* The stem of the contacting part of the commutator is composed of metal powder mixed with graphite, while the other part of the stem is free from graphite or other lubricants.

(3948) German 741,083 (1943). Garbe, Lahmeyer & Co., A. G., *Holder for Brushes on Electrical Machines.* The part is made of a mixture of Fe powder and graphite, pressed and sintered.

(3949) German 742,090 (1943). Ringsdorff-Werke, *Production of Rammed Contacts.* Fe powder, produced by the reduction of Fe_2O_3, is cold rammed into a hole in the graphite brush and around the end of a Cu wire pig tail.

(3950) U. S. 2,331,479 (1943). W. G. Krellner (Stackpole Carbon Co.), *Electrographitic Brush for Collectors.* The brush comprises a mixture of C, a binder, and at least one finely divided hard metal carbide; production involves heating the mixture to the graphitizing temperature, but below the temperature which causes rounding of the sharp edges of the carbide particles.

(3951) German 745,009 (1944). P. Conrath (Siemens-Planiawerke A. G.), *Hardening of Metal-Graphite Commutator Brushes.* After sintering, the brush is exposed to the action of oxidizing gases at temperatures at which the reaction between the metal and O_2 is slow.

(3952) U. S. 2,353,047 (1944). K. Lannert (Carter Carburetor Corp.), *Brushes.* Brushes for electric motors are formed of a conducting material, such as C, combined with a greater conducting material, such as Cu.

(3953) U. S. 2,361,220 (1944). R. S. Loftis (Henrite Products Corp.), *Commutator Brushes.* The brushes are molded from graphite and Cu powder.

(3954) U. S. 2,375,818 (1945). M. F. Peters, *Commutator Brush.* The brush comprises a C body with powdered heavy metal as inert particles.

(3955) U. S. 2,387,073 (1945). A. F. Horlacher (C. P. Clare & Co.), *Rotor for Electric Motors.* The rotor comprises a cylindrically shaped shell composed of a compressed powder of a conducting non-magnetic metal (Cu), and a body of compressed Fe powder in the shell.

(3956) U. S. 2,414,543 (1947). L. E. Moberly (Westinghouse Electric Corp.), *Dynamoelectric Apparatus.* For the collector brushes solid lubricants of metal compounds of S, Se or Te are employed; such compounds are WS_2 or MoS_2, Motelluride or ZrS_2.

(3957) U. S. 2,416,480 (1947). A. C. Henry and J. L. Bitonte (Henrite Products Co.), *Electric Brush.* The brush is composed of 10% melamine resin, 50% Cu dust, 5% Pb dust and 35% graphite.

(3958) U. S. 2,418,812 (1947). F. Girvin (General Electric Co.), *Contact Element for Brushes.* The element is made of a pressed and sintered mixture of graphite with Cu or Ag and S.

(3959) Brit. 616,532 (1949). Bendix Aviation Corp., *Electrical Contact Brushes.* Wear due to reduction of water vapor in the atmosphere at high altitudes is reduced by adding 7% $Ba(NO_3)_2$ to a 40-60 Cu-graphite mixture, and sintering at 800° C. (1470° F.) until $Ba(NO_3)_2$ is converted into BaO.

(3960) U. S. 2,462,055 (1949). R. S. Herwig (Bendix Aviation Corp.), *Brush.* The brush may be formed by adding to a metal-graphite mixture, which may contain 60% C and 40% Cu, an amount of $Ba(NO_3)_2$ equal to approximately 7% by weight of the metal-graphite mixture.

(3961) U. S. 2,465,051 (1949). R. L. Adams and L. Zickrick (General Electric Co.), *Method of Making Electrical Contact Elements.* An electrical brush contact element is composed of carbonaceous material, such as finely divided graphite, and Ag, or a metallic sulphide formed from a mixture of powdered S, graphite, and powdered metal.

C. Resistor Heating Elements

(3962) German 177,252 (1906). Gebr. Siemens & Co., *Shaped Bodies with High Conductivity.* Shaped bodies with a high electric resistivity are produced from SiC by mixing it with powdered free Si.

(3963) U. S. 1,226,470; 1,226,471 (1917). W. D. Coolidge (General Electric Co.), *Refractory Metal Tube as Resistance Element.* A tubular mold is filled with powdered refractory metal, *e.g.* W, and compressed in the radial direction by applying pressure to the inner wall of the mold and sintering the mass into heating

elements. Cu-terminals may be be welded to the elements.

(3964) Swiss 111,867 (1925). C. Conradty, *Resistor Heating Element.* The element consists of a mixture of Ta, Va, Co, Mo and a binder, such as asbestos or kieselgur, which cannot form a carbide; the mixed powders are pressed and sintered.

(3965) German 429,386 (1926). E. Fuchs, *Resistance Furnace.* The furnace with a Mo resistance wire is surrounded by a second container or tube with electric resistance heating, embedded in a mantle filled with graphite powder.

(3966) German 518,666 (1931). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Resistance Furnace.* The furnace has a protective coating of graphite into which the heating coil of Mo or Mo alloys is embedded.

(3967) Austrian 127,351 (1932). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Electrical Resistance Furnace.* The crucible or the furnace chamber which holds the resistance coil is embedded in dense pressed C powder.

(3968) Canadian 322,306 (1932). International Resistance Co., *Resistor.* A bore in an insulator contains a high resistance element; Al powder coated with oxide fills the remainder of the bore.

(3969) German 544,914 (1932). Metallwerk Plansee G.m.b.H. and P. Schwarzkopf, *Resistance Furnace.* Add. to German 518,666 (No. 3966). The graphite or charcoal is mixed with high melting, electric non-conductive oxides.

(3970) U. S. 1,906,963 (1933). A. H. Heyroth (Globar Corp.), *Electrical Resistance Material for Heating Element.* SiC articles are impregnated with metals by heating to the melting point of the metal after surrounding the SiC by the metal.

(3971) Brit. 409,031 (1934). Carborundum Co. Ltd., *Non-Metallic Resistors.* The resistors are composed of SiC, C powder, and Al powder in Na_2SiO_3 solution.

(3972) Brit. 430,117 (1935). H. B. Beer and M. H. Gazan, *Electric Heating Element.* The element is composed of bauxite, graphite and Al powder.

(3973) U. S. 2,003,625 (1935). J. A. Boyer (Globar Corp.), *Silicon Carbide Electric Heating Units.* The units are provided with terminal caps of metal powders containing a substantial proportion of Al.

(3974) German 625,201 (1936). N. V. Molybdenum Co. and P. Schwarzkopf, *Electrode for Resistance Welding.* The resistance body of W, Mo, or Ta has the form of a ribbon winding with grains oriented in the direction of the current; the ribbon is embedded in a lower melting metal.

(3975) Brit. 471,622 (1937). N. V. Molybdenum Co. and H. Bass, *Electric Heating Elements.* An electric heating element of high melting point metal (Mo, W, Ta) is provided with protective coverings which are gas-tight and sintered in an inert atmosphere or vacuum.

(3976) French 827,321 (1938). N. V. Molybdenum Co., *Electrical Resistance Element.* The element consists of Mo, W, or Ta provided with a coating of metal oxide.

(3977) French 829,049 (1938). N. V. Molybdenum Co., *Electrical Resistance Element.* The element consists of a resistance element of a refractory metal in an insulation of refractory oxides forming a vitreous envelope.

(3978) U. S. 2,105,166 (1938). P. Schwarzkopf, *Electrical Heating Element.* Sintered and swaged Mo is embedded in metal-oxide protection tubes and used as resistor bars.

(3979) Austrian 157,232 (1939). Metallwerk Plansee G.m.b.H., *Sealing for Heating Elements.* The Mo resistor wire for Stratit bars is connected with a conductive stud of Cu, Ni or Ag which is built into the ceramic protective casing.

(3980) Austrian 157,558 (1939). Metallwerk Plansee G.m.b.H., *Heating Element for High Temperature Furnaces.* A choking coil is built into the ceramic protective casing and switched between the resistor element and the sealing cap; the choking coil may consist of the same material as the resistor.

(3981) Brit. 510,588 (1939). British Thomson-Houston Co. Ltd., *Resistance Heating Element.* A sintered oxidation-resistant heating element consists of Fe with 5-12% Al.

(3982) Austrian 157,858 (1940). Metallwerk Plansee G.m.b.H., *Heating Element for Electrical Furnaces.* The heating element is so measured that the temperature gradient in the protective casing is not more than 70° C. (160° F.).

(3983) Austrian 157,859 (1940). Metallwerk Plansee G.m.b.H., *Heating Element for High Temperature Furnaces.* The heating element is mounted in a gas-tight ceramic body and consists of Ag or Ag-W so that it is liquid or pasty at the working temperature.

(3984) Austrian 158,269 (1940). Metallwerk Plansee G.m.b.H. and Siemens-Schuckertwerke A. G., *Electric Resistor.* A protecting casing for the resistor consists of two layers; the exterior layer is made of SiO_2; the inner layer is made of metal oxides, *e.g.* Al_2O_3, to make the resistor gas-tight.

(3985) U. S. 2,188,693 (1940). A. J. Thompson (Carborundum Co.), *Manufacture of Silicon Carbide Resistors.* The resistor is formed from a mixture of SiC and subjected to radiant heat from a heating chamber at 2200° C. (4000° F.) in a carbonaceous atmosphere.

(3986) U. S. 2,192,742 (1940). G. H. Howe (General Electric Co.), *Heating Element.* A sintered oxidation-resistant furnace heating element consists principally of Fe, but contains 8% Al and 24-37% Cr previously alloyed with a portion of Fe.

(3987) U. S. 2,193,987 (1940). P. Schwarzkopf, *Electric Heating Element.* A ceramic gas-tight sheathing around the resistor of W, Mo, Ta, has on its ends pin-like bodies of good conductivity, such as Ag, Cu, Ni, or Fe, and a sleeve-like plug fitted on the bodies outside the sheathing.

(3988) Austrian 160,513 (1941). Metallwerk Plansee G.m.b.H. and Siemens-Schuckertwerke A. G., *Production of Electrical Resistors.* Addition to Austrian 158,269 (No. 3984). The resistor of Mo is embedded in a mass containing Si and is heated to the point at which by contact between resistor and embedding mass, an interposition of Si-containing metal is formed.

(3989) Austrian 160,548 (1941). Siemens-Schuckertwerke A. G., *Protective Casing for Electrical Resistors.* The casing for resistors of Mo, W, or Ta consists of Al_2O_3 mixed with bonded SiO_2.

(3990) U. S. 2,242,203 (1941). H. H. Schwarzkopf (American Electro Metal Corp.), *Electric Heating Element.* A ceramic gas-tight cover for the resistor and a hollow metal plug are connected with the adjacent end of the cover, so as to be gas-tight, and engage the resilient end so that a permanent contact is established.

(3991) French 879,832 (1942). R. P. A. Pomiés, *Resistor Element.* The element consists of a mixture of clay, flux and Fe powder which is sintered and used for pressure heating.

(3992) Italian 396,958 (1942). I. Faranda, *Electrical Resistance with a Conductor of Iron Embedded in Cement.* Instead of more expensive Ni-Cr alloys, the use of plain Fe embedded in a cement block is claimed for uses entailing temperatures not exceeding 300° C. (570° F.).

(3993) U. S. 2,294,755 (1942). H. Inutsuka and S. Kawase (General Electric Co.), *Sintered Metal Oxide Compositions.* An electrical resistance material suitable for time-delay relaying devices, and having a negative temperature coefficient of resistance, consists of 95-60% of powdered CuO and 5-40% Cr_2O_3; the mixture is sintered at 1500° C. (2730° F.).

(3994) U. S. 2,294,756 (1942). H. Inutsuka and S. Kawase (General Electric Co.), *Resistant Body.* An electrical resistor is produced by sintering above 1000° C. (1830° F.) a molded mixture of paraffin, powdered Cu and Cr_2O_3.

(3995) French 882,878 (1943). N. V. Philips' Gloeilampenfabrieken, *Electrical Resistor.* The resistor consists of a mixture of MgO and TiO_2 sintered at 1700° C. (3090° F.) in a reducing gas, whose O content is regulated according to the value of the resistance.

(3996) French 884,351 (1943). Zeiss Ikon A. G., *Production of Bodies of High Ohmic Resistivity.* A mixture of conductive metal and a hardening binder material is pressed through a nozzle and sprayed on a support of insulating material.

(3997) French 886,749 (1943). Fides Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Electrical Resistance for High Temperatures.* A porous ceramic body is impregnated with a metal which is non-oxidizable in air.

(3998) French 887,392 (1943). Fides Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Electrical Resistance for High Temperatures.* For the production of a resistance of 1,000 ohms, mixtures of ceramics, C and metal particles having an initial resistance of 50 ohms are used.

(3999) French 887,597 (1943). Fides Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Electrical Resistance for High Temperatures.* A porous ceramic body is infiltrated with Ag or Pt, or with $AgNO_3$ which is dissociated by heating.

(4000) German 744,579 (1944). Vereinigte Deutsche Metallwerke A. G., *Heating Elements by Sintering.* Ni-Cr wire made from powders with minute additions up to 2% of Ca, Mg, Ba, Be and up to 5% Zr, U or Th, have longer life than cast alloy materials. Sintered compacts can be forged after 30% reduction, hot-rolled after 40% reduction.

(4001) U. S. 2,338,531 (1944). E. J. Naumann and J. E. Gilhooly (Westinghouse Electric & Mfg. Co.), *Resistor.* A resistor has a coating of Al powder applied to the inner surface of the support.

(4002) U. S. 2,347,796 (1944). L. Podolsky (Sprague Products Co.), *Electrical Resistor.* The resistor is molded from an inert filler, conductive particles such as C and a binder.

(4003) U. S. 2,358,406 (1944). F. Lichtgarn, *Resistant Element.* The element comprises metal oxide, SiO_2 and finely divided Al powder.

(4004) Brit. 574,088 (1945). Mond Nickel Co. Ltd. and L. B. Pfeil, *Resistor Heating Element.* The element is made of a heat-resisting Cr alloy and has a surface of a gas-permeable film, consisting of oxides of Th, Ca, Zr.

(4005) U. S. 2,371,211 (1945). R. R. Barrington (General Motors Co.), *Resistor.* A resistor comprises a bonded mixture of finely divided SiC, a conductive metal powder and a glassy bonding element.

(4006) U. S. 2,372,212 (1945). G. Lewin (American Electro Metal Corp.), *Electrical Heating Element.* The element consists of an evacuated and sealed gas-tight refractory tube containing a coiled electrical resistor which has been coated with a mixture of powdered refractory material (oxides or silicates of Al, Mg, Ti) and a powdered Zr or Th base getter.

(4007) U. S. 2,406,275 (1946). A. R. Weynarth, *Resistance Element.* Sintered metals are used for electric resistance elements.

(4008) Brit. 592,365 (1947). Comp. de Produits Chimiques et Électro Métallurgiques, *Resistors for Electric Heating.* Mo resistor bars are made by sintering a 70:30 mixture of Mo and Mg powders in form of a porous tube encased in a sleeve of pure MgO, with a protective gas supplied through the tube.

(4009) Brit. 595,060 (1947). American Electro Metal Corp., *Electrical Heating Elements.* Coiled W or Mo resistor wire is coated with a 1:2 mixture of Zr powder and Al_2O_3. The wire is placed in a ceramic tube with leads arranged at one or both ends. The tube is then evacuated, sealed off, and positioned through an aperture in the furnace wall.

(4010) U. S. 2,418,461 (1947). J. A. Becker, H. Christensen and J. J. Kleimack (Bell Telephone Laboratories Inc.), *Resistor.* A resistor with a connecting lead has, on its surface, a layer of Pt and a second Pt layer securing the lead with the body, which is formed by heating while in place a pasty layer comprising a Pt-compound reducible by heat mixed with Pt.

(4011) Brit. 611,515 (1948). A. B. Kanthal, *Heat-Resisting Machinable Alloy for Electric Resistance Material.* Grain growth in Fe-Cr alloys containing Al, Co, Ni and Si is prevented by adding oxide or carbide powder to the melt, or by preparing the alloy entirely from powder.

(4012) Austrian 162,873 (1949). Metallwerk Plansee G.m.b.H., *Electrical Resistor for High Temperature Furnaces.* A resistance wire of Mo, W, Ta, Cb and the supporting rods of sintered Al_2O_3 forms a wickerwork, whereby the wire has no free ends.

(4013) U. S. 2,470,352 (1949). T. Holmes (The Hartford National Bank & Trust Co.), *Electrical Resistor.* An electrical resistor uses a cement that consists of Ag-Cu powder suspended in a binder for securing the lead-in elements in position.

(4014) U. S. 2,479,914 (1949). L. D. Drugmand and E. W. Seeger (Cutler-Hammer, Inc.), *Resistance Heater Unit For Thermal Overload Devices.* The device is made up of concentric outer and inner tubular metal members of circular form in cross section. They are electrically connected by a body composed of a mixture of conducting and non-conducting materials in powdered form. The conducting materials may be Ni, Fe, Ag, W, and the like, while the non-conductive components may be bentonite or kaolin. The devices may be molded and sintered, in which case a blue frit may be added.

D. Porous Electrodes and Electrical Products

(4015) U. S. 289,386 (1883). W. E. Case, *Porous Electrodes.* Porous electrodes for secondary batteries are produced by cooling, pressing and molding partly molten metal powders.

(4016) U. S. 295,456 (1884). E. T. Starr, *Porous Electrodes.* Battery electrodes are made from an amalgam of Pb filings, PbO_2 and Hg.

(4017) U. S. 413,438 (1889). F. F. Eggers, *Battery Zinc.* Battery Zn is produced by adding pulverized Zn to dilute H_2SO_4 and Hg, and compressing without heat.

(4018) U. S. 440,173 (1890). A. J. MacDonald and H. E. Townsend, *Battery Zinc.* Battery Zn is produced by adding to it an amalgam, previously hardened by adding Zn in small pieces, and adding a portion of the pre-alloy to the molten Zn, casting the mixture and adding then powdered Mg.

(4019) U. S. 645,261 (1900). F. K. Irving and A. G. Vogt, *Porous Battery Electrode.* The electrodes are produced from a mixture of Pb shavings, Hg, and pulverized Zn.

(4020) Brit. 194,355 (1923). K. Katsumori, *Manufacture of Porous Metallic Bodies for Nickel Accumulators.* An alloy of 97% Ni and 3% Mg in form of a plate is heated in a centrifugal separator, so that the partly liquefied portion of the alloy, constituting the eutectic, is driven out.

(4021) German 422,461 (1925). H. Wolff, *Electrolytic Production of Chromium.* Cr anodes are produced from pressed and sintered powder.

(4022) Belgian 351,859 (1928). A. Gregoire, *Porous Metallic Plates or Objects, Particularly for Storage Batteries.* A granular mass, *e.g.* of Ni, is heated in a mold and sintered, thus causing partial coalescence at the points of contact.

(4023) German 469,917 (1928). I. G. Farbenindustrie A. G., *Electrode for Storage Batteries.* The active mass is coated with metal powders produced from metal carbonyls.

(4024) Brit. 311,141 (1929). I. G. Farbenindustrie A. G., *Production of Porous Metal Articles from Metal Powder.* Products suitable for use as electrodes of alkaline storage batteries, or as diaphragms or filters, are made by subjecting finely divided metals, obtained by decomposition of metal carbonyls, to heat or pressure or both. The heating may be effected in H_2 or an inert atmosphere. For example, Ni powder, prepared from Ni carbonyl, is heated to 500° C. (930° F.) for 24 hrs. in H_2, and at the same time pressed at 40 kg./cm.^{2} (570 psi) to a porosity of 30%.

(4025) Brit. 326,536 (1930). I. G. Farbenindustrie A. G., *Porous Metal Articles, Such as Electrodes for Storage Batteries.* Addition to Brit. 311,141 (No. 4024).

(4026) Brit. 332,052 (1930). I. G. Farbenindustrie A. G., *Porous Metal Articles Such as Storage Battery Electrodes.* Metal powders (Fe, Ni, Cu, Co), reducible oxides, or carbonates are sintered at low temperature (500-700° C; 930°-1290° F.) and then further sintered at higher temperature (800-1200° C.; 1470-2190° F.) in a reducing atmosphere or vacuo.

(4027) French 690,485 (1930). I. G. Farbenindustrie A. G., *Porous Metal Electrodes.* Electrodes from metal powders of Fe or Ni are fritted first at 650° C. (1200° F.) and then heated and sintered at 1200° C. (2190° F.).

(4028) German 491,498; 493,593 (1930). I. G. Farbenindustrie A. G., *Electrode for Storage Batteries.* The electrodes are produced by immersing the active mass into the pores of a metal pressing.

(4029) German 498,611 (1930). I. G. Farbenindustrie A. G., *Production of Electrodes for Storage Batteries.* Addition to German 491,498 (No. 4028). The precipitation of the active mass from its compounds occurs inside of the pores of the metal body, whereupon the soluble residues are washed out.

(4030) German 503,807 (1930). E. Maas and M. Schlötter, *Production of Chromium Anodes.* Cr_2O_3 is pressed and then reduced in H_2, crushed, pressed and sintered.

(4031) Brit. 361,164 (1931). I. G. Farbenindustrie A. G., *Improvements in Electrodes for Electric Accumulators Having Alkaline Electrolytes.* A negative electrode for accumulators having an alkaline electrolyte is of porous structure, which is manufactured from iron powder by sintering.

(4032) Canadian 308,351 (1931). I. G. Farbenindustrie A. G., *Highly Porous Lead.* A homogeneous alloy of Pb and Na is treated with alcohol, to produce a Pb body with 45-70% pores which may be used for anodes for batteries.

(4033) German 519,456; 519,727 (1931). I. G. Farbenindustrie A. G., *Electrode for Storage Batteries.* Improvement of German 491,498 (No. 4028). Porous pressings of an Cu-Ni alloy are used for electrodes.

(4034) German 523,029 (1931). I. G. Farbenindustrie A. G., *Material for Porous Electrodes of Metal Oxide Powders.* The metal oxide powders are mixed with metal powders at an elevated temperature at which the oxidation of the metal starts.

(4035) Brit. 380,242 (1932). I. G. Farbenindustrie A. G., *Improvements in Manufacture and Production of Electrodes for Electric Storage Batteries.* A method of production of electrodes for storage batteries consists in imparting high electric capacity to coherent porous Fe bodies without use of Cd by anodic and cathodic treatments and subsequently introducing Cd compounds into the pores.

(4036) German 583,869 (1933). I. G. Farbenindustrie A. G., *Electrodes for Accumulators.* Metal powders from carbonyls, *e.g.* Fe, are mixed with other powdered ingredients, *e.g.* NaCl, and heated in H_2. After cooling the porous mass is leached.

(4037) German 608,122 (1935). I. G. Farbenindustrie A. G., *Production of Porous Bodies.* Metal powders are presintered at 650° C. (1200° F.) to make the mass plastic, and then sintered at 800-1200° C. (1470-2190° F.); products are suitable for battery plates, electrodes, etc.

(4038) U. S. 1,988,861 (1935). E. Thorausch and L. Schlecht (I. G. Farbenindustrie A.G.), *Production of Metallic Plates Suitable for Use as Accumulator Electrodes.* Porous metal plates are made by mixing metallic powder obtained from carbonyls with 5% additional material which is later removed from the mass; the uncompressed mixture is subjected to sintering.

(4039) Brit. 445,982 (1936). E. Schattaneck, *Electrodes and Electrical Contacts.* A porous metal body is impregnated with switch or quenching liquid, which causes a rapid diminution of intensity in the arc.

(4040) Austrian 148,917 (1937). E. Schattaneck, *Electrical Switch.* The contacts consist of a porous metal or metal alloy, which may be impregnated with a fluid used in the switching device, either before or during the separation of the electrodes.

(4041) Austrian 149,314 (1937). E. Schattaneck, *Electrodes or Contacts for Welding Machine Shock Loading Generators.* The electrodes consist of a porous metal or metal alloy and may be impregnated with a fluid used in the switching device.

(4042) Brit. 468,518 (1937). Accumulatoren-Fabrik A. G., *Production of Porous Metal Bodies.* Hammer scale is mixed with tar and charcoal to a plastic mass,

rolled into strip and heated, then steam and later H_2 is passed through the chamber to produce a porous sheet, suitable for porous electrodes, etc.

(4043) Brit. 492,060 (1938). A. Behr, *Porous Electrodes for Electrolytic Condensers.* Electrodes are pressed from Al powder and sintered to form a coherent porous solid.

(4044) Brit. 497,844 (1938). I. G. Farbenindustrie A. G., *Porous Metal Bodies for Batteries.* Porous metal bodies are obtained by using Fe powder whose loading (pouring) weight amounts to less than 2.0 g./cc., and sintering it above 650° C. (1200° F.).

(4045) German 666,010 (1938). Accumulatoren-Fabrik A. G., *Porous Metal Articles.* A method of producing formed porous metal bodies, suitable for battery elements, consists of grinding metal oxide powders with paraffin oil and charcoal which absorbs the gases liberated during heating.

(4046) U. S. 2,180,988 (1939). E. Lemmers and G. M. Carpenter (General Electric Co.), *Electrode for Discharge Devices.* The production process comprises forming a porous body by compression of coarse refractory metal particles and momentarily passing a heavy electric current to weld the particles together only at their contacting edges, and impregnating the body with an electron emissive material.

(4047) German 687,549 (1940). H. H. Armstrong and A. B. Menefee, *Electrodes.* A powdered mixture of WC, W metal and/or WO_3 with an alloying metal is used as an anode in an aqueous fluoride bath, either as a loose mass in a perforated container or the mass is pressed and sintered with a binder into a porous body.

(4048) German 708,895 (1941). Siemens & Halske A. G.. *Electrolytic Condenser.* Porosity of electrodes is preserved or increased by mixing Al powder with 5-20% camphor dissolved in ether, pressing the dried powder at 10-20 tsi and presintering it to drive off the camphor.

(4049) U. S. 2,240,821 (1941). J. L. Young (Plastic Metals, Inc.), *Iron Anodes.* Fe anodes of a porous cellular structure for electrolytic cells are produced by compressing and reducing oxide-coated sponge Fe granules.

(4050) U. S. 2,244,436 (1941). C. Tietig, *Electric Contact.* Porous electrical contacts are manufactured from a powdered metal and the pores are impregnated with a lubricant.

(4051) German 721,887 (1942). I. G. Farbenindustrie A. G., L. Schlecht and K. Ackermann, *Porous Nickel Electrode for Secondary Elements.* Electrodes are made from carbonyl Ni powder with an apparent density of less than 2 g./cc. and preferably in the range of 0.5 to 1, by first presintering below 700° C. (1300° F.) followed by one or more sintering operations at a higher temperature, preferably between 800 and 1200° C. (1470 and 2200° F.). If presintering is omitted, the sintering temperature should lie above 650° C. (1200° F.).

(4052) Italian 395,824 (1942). A. Bagnasco and G. Lando, *Generating Apparatus or Storage Battery for Electricity.* The apparatus in question has two special porous plates of suitable contours consisting of a metal (Al, Fe, Ni, Pb, or the like) finely powdered and mixed with some of its oxygenated solid and powdered components.

(4053) U. S. 2,283,723 (1942). R. U. Clark (Magnavox Co.), *Porous Electrodes.* Nonsintered electrodes comprising hard basic powders are encased in a thin shell of softer material by ball milling.

(4054) U. S. 2,299,228 (1942). D. E. Gray and J. O. Ollier (Radio Patent Corp.), *Electric Condenser.* The condenser is produced by pressing metallic particles into a porous spongy body.

(4055) German 732,433 (1943). Siemens & Halske A. G., *Porous Electrical Contact.* A high melting metal, such as W, Mo, Ta, is mixed with a low melting metal, such as Fe, Ni, Cu, that will evaporate at sintering temperature of the former, *e.g.* 1700° C. (3090° F.). The sintering is carried out in vacuum or in protective atmosphere.

(4056) Swiss 226,001 (1943). O. Vieli and G. Lorenz, *Metallic Diaphragm for Electrolysis.* Metal powders are placed on a metallic base, sintered, and lifted off the base.

(4057) Swiss 227,592 (1943). Deutsche Gold- & Silberscheideanstalt, *Production of Porous Silver Anodes.* An Ag powder which passes through a sieve with 16,000 openings to a sq. cm. is used for the production of porous anodes.

(4058) U. S. 2,325,201 (1943). J. L. Young (Plastic Metals Inc.), *Electrolytic Cell.* Soluble and porous anodes for electrolytic cells comprise Fe granules united by bridges of metallic Fe.

(4059) German 747,370 (1944). Deutsche Gold- & Silberscheideanstalt, *Soluble Silver Anode.* Porous anodes are made from minus 325 mesh electrolytic Ag powder by pressing at 3 tsi. A porosity of 40% permits a current density of 30-40 amps./ft^2.

(4060) U. S. 2,359,970 (1944). R. U. Clark (Magnavox Co.), *Porous Condenser Electrode.* The electrode is formed of pressed metal powders of Ta.

(4061) U. S. 2,361,378 (1944). J. B. Brennan, *Porous Electrode.* An electrode comprises a conductive layer of metal powders bonded together and having a filler material present in the interstices prior to immersion in an electrolyte.

(4062) U. S. 2,366,402 (1945). A. Hauel, *Negative Electrode.* A negative porous electrode for Cd-Ni batteries utilizes finely divided Fe.

(4063) U. S. 2,367,453 (1945). H. D. Wilson (Electric Auto-Lite Co.), *Porous Electrode.* Storage battery electrodes include PbO particles in a paste mixed with 0.1-3% ammoniated sulfite pulp waste liquor solids.

(4064) U. S. 2,379,374 (1945). P. D. Payne, *Electrical Cell for Nickel-Iron Batteries.* Finely divided Fe is used with Hg in laminated porous cells of storage batteries.

(4065) U. S. 2,384,463 (1945). R. Gunn and W. C. Hall, *Electrode.* The electrode of a fuel cell is coated with sintered metal particles, *e.g.* Ni or NiO, comprising in combination a perforated or meshlike electrically conductive member, to which the sintered metal particles are bonded, and which are provided with a catalytic coating for promoting a gaseous ionization.

(4066) U. S. 2,389,893 (1945). M. F. Chubb and P. C. Ebert (Eagle-Picher Co.), *Battery Plates.* Porous storage battery plates are made of finely divided spongy Pb.

(4067) U. S. 2,404,824 (1946). J. M. Booe (P. R. Mallory & Co. Inc.), *Electrolytic Condenser.* An electrode is formed of a porous base carrying a coherent adhering layer of finely divided film-forming metals.

(4068) Brit. 586,967 (1947). Morgan Crucible Co. Ltd. and C. R. Wright, *Method of Securing Bodies Together.* Split bushes produced from a strip of porous and malleable sintered bronze are used for screw contacts.

(4069) U. S. 2,414,836 (1947). E. W. Rickmeyer (Jefferson Electric Co.), *Timing Unit for Centrifugal Switches.* A good low resistance connection through Hg is obtained by using a wafer of porous sintered metal which will amalgamate somewhat with Hg, at such rate as not to affect the flow of Hg; the center contact has a core of Monel metal with a Cu sleeve.

(4070) U. S. 2,422,045 (1947). S. Ruben, *Alkaline Dry Cell.* The cell has an amalgamated Zn anode, a cathode of reducible metal oxide and permanganates, and an alkaline electrolyte containing dissolved Zn; the cathode is covered by a minutely porous and ionically permeable barrier of powdered metal.

(4071) U. S. 2,429,987 (1947). J. B. Brennan, *Porous Electrolytic Condenser.* The electrolyte permeates the interstices of porous spacers and the porous spray layer of Al, to result in a high capacity.

(4072) U. S. 2,431,964 (1947). E. W. Rickmeyer (Jefferson Electric Co.), *Mercury Switch.* In a delayed-action centrifugal Hg switch suited for low-spin operation. One of two chambers is replaced by a porous plug of sintered Fe or Ni.

(4073) U. S. 2,432,513 (1947). C. Depew (Bell Telephone Laboratories Inc.), *Ionic Discharge Device.* The device has an anode centrally mounted within the enclosing vessel and operatively spaced in relation to a porous sintered metallic mass, *e.g.* Fe powder, anchored in the cathode cup and saturated with Hg.

(4074) Brit. 604,746 (1948). Standard Telephone & Cables Ltd., *Composite Selenium Electrode.* The anode for a Se plating bath is made of a pressed and

sintered mixture of Se and C powders which is placed inside a porous container of sintered glass.

(4075) Brit. Appl. 13448/48 (1948). Accumulatoren Fabriek Varta N. V., *Accumulator Plates Sintered from Metal Powder.* Porous Ni or Cu plates are made by welding an arched piece of gauze to a metal frame, bedding the gauze in metal powder, and sintering lightly, coining the sintered powder to the frame, and the central section to shape, and sintering again.

(4076) U. S. 2,436,601; 2,436,602 (1948). E. W. Rickmeyer (Jefferson Electric Co.), *Switch Element.* An Hg switch of the centrifugal type with a time delay element has two chambers separated by a wafer of porous sintered Ni or steel.

(4077) Brit. Appl. 11951/49 (1949). H. Vogt, *Electrodes for Alkaline Batteries.* Porous sintered electrode strip of Ni or Fe is made by coating the foil with a suspension of the respective powders in a liquid adhesive, followed by heating.

(4078) U. S. 2,458,878 (1949). S. Ruben, *Alkaline Primary Cell.* The anode of this alkaline primary cell is a porous mass formed from amalgamated Zn powder.

(4079) U. S. 2,461,410 (1949). R. U. Clark (The Magnavox Co.), *Porous Electrode for Electrolytic Cells.* One mixture used for the electrode consists of 3 parts of Al powder, 4 parts of Ta_2O_5 and 2 parts of Ta powder (400 mesh).

E. Miscellaneous Electrical and Electronics Products

(4080) Brit. 180,090 (1922). Western Electric Co., *Thermionic Cathodes.* An electron-emitting cathode with a core of 95% Pt and 5% Ni is coated with a thermionically active material containing carbonates of Ba or Sr and heated in vacuum.

(4081) Brit. 193,329 (1923). N. V. Philips' Gloeilampenfabrieken, G. Holst and D. Lely, *Leading-In Conductors for Vitreous Material.* The conductors consist of two or more different metal powders which are so chosen that the conductor, produced from the sintered body, has the same coefficient of expansion as that of the vitreous material.

(4082) French 682,159 (1930). I. G. Farbenindustrie A. G., *Metals for Electrical Apparatus.* Sintered metals from carbonyl powders, *e.g.* Ni, are used for electrical apparatus.

(4083) U. S. 1,947,112 (1934). S. Ruben (Ruben Condenser Co.), *Electric Condenser.* The dielectric material is made from a mixture of Al powder with an oxidized surface or metal oxides and boric acid and a varnish of synthetic resin.

(4084) German 618,917 (1935). Radio-Röhren Laboratorium Dr. Nickel, *Cathode with Indirect Heating.* The material of the insulator is mixed with Al powder as a reducing agent.

(4085) Brit. 482,586 (1938). N. V. Molybdenum Co., *Shaped Bodies for Electric Purposes, Particularly Lead-In Wires and Bars for Electric Current.* A spark plug is provided with a conductor consisting of a highly sintered alloy of pure Ni, Co and Fe plus 0.3% Si, Mg or C.

(4086) U. S. 2,172,548 (1939). P. Schwarzkopf, *Shaped Bodies for Electrical Purposes.* The bodies consist of 20-30% Ni, 10-20% Co, 50-70% Fe, with impurities below 0.3%, and are sintered at 1300-1400° C. (2370-2550° F.), then rolled to wires. Because of their low coefficient of expansion they are suitable for lead-in wires and bars for electrical current.

(4087) Norw. 66,266 (1940). C. Lorenz A. G., *Method for Manufacture of Tube-Like Cathodes for Thermionic Tubes.* A process for the production of Th alloyed W cathodes is described.

(4088) U. S. 2,300,959 (1942). M. Pirani (General Electric Co.), *Cathode.* The cathode is formed from Ba aluminate or chromate with Zr powder as a reducing agent.

(4089) Belgian 451,491 (1943). Patentverwertungs G.m.b.H. Hermes, *Selenium Rectifiers.* The device uses an electrode coated with powdered Se.

(4090) Canadian 436,090 (1943). Federal Telephone & Radio Corp., *Selenium Rectifier.* Powder for the rectifier is made from a fused mixture of Se powder and Se-halide.

(4091) Dutch 55,287 (1943). Licentia Patent-Verwaltungs-Gesellschaft m.b.H., *Non-Emitting Electrode for Electrical Discharge Apparatus.* A method for making a high-melting electrode for an electrical discharging tube is characterized in that there is applied to the electrode a mixture of Zr and/or Cb, possibly in conjunction with Ta, with C from C-containing, (preferably organic) compounds; this mixture is sintered so that a carbide is formed on the electrode.

(4092) Dutch 55,507 (1943). Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H., *Method for Making a Getter Element for Electrical Discharge Apparatus with an Alkaline-Earth-Aluminum Alloy.* Th and Ti take the place of the conventional materials reacting with the Al.

(4093) Swedish 109,285 (1943). Lumalampan A. B., *Method for Making Activated, Preferably Self-Heating Electrodes.* The electrodes contain endothermic oxides, made up of a thermit mixture.

(4094) U. S. 2,307,474 (1943). L. E. Thompson (Union Switch & Signal Co.), *Selenium Rectifier.* The rectifier is made from powdered Se and a nonvolatile chloride salt.

(4095) U. S. 2,319,364 (1943). P. Ziegs, *Electrical Heating Conductor.* The conductor is composed of metal powders of the Pt group coated with powdered metal of the earth and alkaline metals.

(4096) U. S. 2,321,523 (1943). O. Saslaw (Federal Telephone & Radio Corp.), *Method of Reclaiming Selenium Elements.* A plate coated with Se and with a counter electrode of Se, which has broken down under voltage, is reclaimed by pressing on Se powder at a high temperature.

(4097) U. S. 2,330,620 (1943). E. Presser, *Photoelectric Cell.* The cell comprises finely divided Al and Au applied to a base of Se.

(4098) U. S. 2,331,098 (1943). J. W. White and R. Harrison (Bendix Aviation Co.), *Tube Clamp.* A conduit holder has a cushion of electrically conductive material, such as Al powder.

(4099) U. S. 2,332,809 (1943). L. R. Peters (General Electric Co.), *Glow Switch.* A thermal switch of gaseous electric discharge type employs Al powder.

(4100) German 745,979 (1944). Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H., *Thorium Cathode.* Porous tubes of W or Mo are impregnated with Th by heating in vacuum in the presence of Th wire or powder.

(4101) U. S. 2,339,392 (1944). L. P. Garner (Radio Corp. of America), *Cathode.* The cathode comprises a layer of powdered refractory metal particles sintered to the base, and ThO_2 particles intermingled with the sintered particles.

(4102) U. S. 2,339,613 (1944). J. A. Becker and J. N. Shive (Bell Telephone Laboratories), *Selenium Rectifier.* The rectifier is composed of Se powder deposited on a backing member of Ni and Fe.

(4103) U. S. 2,342,278 (1944). H. Herrmann, *Selenium Cell.* The cell is produced by placing a layer of amorphous Se powder on a base plate and pressing together at a high temperature.

(4104) U. S. 2,348,311 (1944). S. Ruben, *Electrode.* A dry rectifier electrode is formed to a disk of a dense structure with Cu_2S made by heating Cu powder with S.

(4105) U. S. 2,353,635 (1944). J. O. Aicher (General Electric Co.), *Cathode.* The cathode is made from metal powder added to an activating mixture, such as $BaCO_3$ or BaO.

(4106) U. S. 2,356,094 (1944). O. Saslaw (Federal Telephone & Radio Corp.), *Selenium Element.* An adherent layer of Se is applied to a rough-surfaced base plate of Fe by melting Se powder and spreading it over the surface.

(4107) U. S. 2,357,602 (1944). M. F. Peters and F. I. McCarthy, *Spark Plug.* A spark plug having compressed metal powders disposed adjacent to the spindle shank prevents gases from pressing into the interior of the plug.

(4108) U. S. 2,364,642 (1944). A. J. Miller and I. R. Taylor (Federal Telephone & Radio Corp.), *Selenium Element.* A Se rectifier comprises compressed Se powder against a base plate at elevated temperatures.

(4109) U. S. 2,368,060 (1945). L. A. Wooten (Bell Telephone Laboratories), *Electron Discharge Tube.* A nonemissive electrode for discharge devices has a coating of finely divided Zr with SiO_2 binder and a metallic base.

(4110) U. S. 2,370,443 (1945). K. Biefeld, *Nonmetallic Electric Resistance Material.* A nonmetallic electric resistance material consists of a sintered mass of spinels comprising Cd-ferrite and Al_2O_3.

(4111) U. S. 2,370,493 (1945). O. Saslaw (Federal Telephone & Radio Corp.), *Selenium Element.* The element is produced by applying to Se small amounts of water before the application of the counterelectrode.

(4112) U. S. 2,373,395; 2,373,396 (1945). J. R. Hefele (Bell Telephone Laboratories), *Electron Discharge Device.* A target structure for an electron discharge device comprises a conducting backing element of Ag, and an insulating material with metal powders and photo-sensitive material added.

(4113) U. S. 2,375,211 (1945). J. B. Brennan, *Electrode for Condensers.* A conductive layer of finely divided metal powders is bonded to a metallic base.

(4114) U. S. 2,376,757 (1945). A. Chanosky, *Electrical Resistor.* An electrical resistor is composed of a compressed mixture of reduced metallic Fe in granular form and TiO_2; granules of Fe are substantially insulated from one another by the TiO_2.

(4115) U. S. 2,377,164 (1945). R. Lowit (Callite Tungsten Corp.), *Electrical Assembly.* An electrical assembly for leading-in current in lamps or radio tubes contains Fe wire coated with a thin film of Cu powder.

(4116) U. S. 2,378,438 (1945). O. Saslaw and H. Carlson (Federal Telephone & Radio Co.), *Selenium Element.* A rectifier contains powdered Se sintered to a base plate.

(4117) U. S. 2,380,505 (1945). H. B. De Vore (Radio Corp. of America), *Electrode for Television Tubes.* Oxidized metallic particles are treated with alkali metal in forming two-sided mosaic electrodes.

(4118) U. S. 2,383,384 (1945). J. C. Harris, *Induction Furnace.* A metallurgical induction furnace can be made self-starting if powdered metal is used to complete the secondary circuit.

(4119) Brit. 578,208; 582,214 (1946). Standard Telephones & Cables Ltd. and H. Carlson, *Selenium Element.* Adherence of Se powder to the base is improved without prejudice to its electrical properties by heating the platens of the press to different temperatures during compression. The Se powder may be blown under pressure on a heated base plate.

(4120) Brit. 582,385 (1946). Standard Telephone & Cables Ltd. and C. A. Kotterman, *Dry Rectifier Element.* The element utilizes a base plate with circumferential rims which determines the thickness of the layer of Se during the pressing.

(4121) U. S. 2,394,865 (1946). F. I. McCarthy and C. Schandler, *Sparking Plug.* The ceramic member of a spark plug has a compression ring formed of powdered Cu.

(4122) U. S. 2,399,773 (1946). S. J. Waintrob, *Method of Making Electrical Rectifiers and the Like.* A solid oxide-coated Cu disk is formed by placing Cu powder in a mold and compacting, then placing a mixture of powdered Cu and CuO powder in the mold on top of the first layer, compacting the mixture and then heating the mold and contents under non-oxidizing conditions.

(4123) U. S. 2,403,026 (1946). O. Saslaw (Federal Telephone & Radio Corp.), *Selenium Tablet.* Powdered Se for cells is compressed into a wafer and then converted to metallic form by heating.

(4124) U. S. 2,404,802 (1946). J. P. Laico and V. L. Ronci (Bell Telephone Laboratories), *Electron Discharge Device.* A Cs pellet is used in a photoelectric tube; the pellet contains Cs_2CrO_4, Cr_2O_3 and powdered Al.

(4125) U. S. 2,404,803 (1946). A. E. Stafford (Western Electric Co.), *Space Discharge Device.* Powdered Al, Cs_2CrO_4 and Cr_2O_3 are compressed to form a pellet.

(4126) U. S. 2,405,089 (1946). P. H. Craig (Invex Inc.), *Gaseous Discharge Device.* Powdered Pt, Au and Ag are used to make metallic glass for gaseous discharge tubes.

(4127) U. S. 2,405,349 (1946). W. Freund, *Accumulator.* A mixture of Zn powder, ZnO and HgO is used in an accumulator for electric torches or flash lamps.

(4128) Brit. 584,270 (1947). General Motors Corp., *Alloys or Metallic Mixtures for Electrodes.* Electrodes for gaseous discharge tubes are made from a 100:10 mixture of H_2-reduced Fe powder and BaO_2.

(4129) Brit. 590,458 (1947). Western Electric Co., *Rectifiers of Silicon.* Si rectifiers are made by fusing highly pure Si powder by adding 0.1-0.5% SiC in an SiO_2 crucible and in He atmosphere.

(4130) U. S. 2,414,099 (1947). M. S. Glass, V. L. Ronci, and E. J. Walsh (Bell Telephone Laboratories), *Space Discharge Device.* Cs for sensitizing the cathode is produced by chemical reaction of a mixture of ingredients in form of a pellet.

(4131) U. S. 2,416,297 (1947). T. R. Finch and D. A. McLean (Bell Telephone Laboratories), *Wave Transmission Network.* The network comprises a form of insulating material with sets of condenser electrodes constituted by metallic coatings, extending part way around the form and between layers of dielectrics, made of vitreous enamel; the electrodes are formed of Ag paste and fired in place.

(4132) U. S. 2,419,966 (1947). C. E. Ransley, J. W. Ryde, and S. V. Williams (General Electric Co. Ltd.), *Crystal Contact.* The contact is made by grinding Si and treating it with reagents to remove the impurities; the pure product is fused with pure BeO in an inert atmosphere.

(4133) U. S. 2,421,984 (1947). E. N. Bobrow (Radio Corp. of America), *Material for Gettering Electron Discharge Devices.* Ba-titanate is prepared by mixing $BaCO_3$ with TiO_2 and sintering at 1250° C. (2280° F.) for 4-6 hours; the product is powdered and mixed with Be powder and cellulose binder.

(4134) U. S. 2,422,038 (1947). J. F. Parisot (S. A. Le Carbone Lorraine), *Anodes for Intensive Arcs.* A thick paste of C, pulverized ferrosilicon and an organic binder is injected into C sheaths and then baked to harden the core.

(4135) U. S. 2,423,290 (1947). W. F. Bonwitt (Burndy Engineering Co.), *Electric Connector for Cables.* The connector has a tubular body filled with a mixture of powdered Zn, Ca, and Mg.

(4136) U. S. 2,423,297 (1947). T. R. Finch and D. A. McLean (Bell Telephone Laboratories), *Wave Transmission Network.* The network comprises a form of insulating material, with a first set of metal powder coatings as condenser electrodes, extending part way around the form at spaced intervals along the length, a layer of dielectric over the electrodes, and a second layer of condenser electrodes, over the dielectric layer.

(4137) U. S. 2,424,995 (1947). A. J. Miller and O. J. Mueller (Federal Telephone & Radio Corp.), *Selenium Element.* The element is formed by pressing against the top surface of a Se-coated plate a hydrated oxide-coated Al sheet, formed by anodizing the Al surface in a H_2SO_4 solution.

(4138) U. S. 2,427,183 (1947). K. L. Berry (Du Pont De Nemours & Co.), *Electric Insulation.* Insulating material is produced by applying solid polytetrafluoroethylene between layers of powdered Si and subjecting the laminae to heat and pressure, then rapidly cooling.

(4139) U. S. 2,429,655 (1947). A. von Hippel and J. H. Schulman (Federal Telephone & Radio Corp.), *Selenium Element.* The anodic treatment of a Se surface has the advantage of placing a blocking layer on the surface of a thickness and quality which can be controlled by the factors associated with the plating base, current flow and the time of treatment.

(4140) U. S. 2,433,401 (1947). O. Saslaw (International Telephone & Radio Corp.), *Selenium Paste for Rectifiers.* The paste consists of a mixture of red amorphous Se powder, vitreous Se powder and a volatile liquid carrier of methyl alcohol.

(4141) Brit. 596,404 (1948). Standard Telephone & Cables Ltd., *Metal Contact Rectifiers.* A sintered mixture of 61% Sn and 39% Cd is used as base plate and counter-electrode for Se rectifiers.

(4142) Brit. 598,589 (1948). Standard Telephones & Cables Ltd., *Selenium Rectifiers.* The Se powder is placed on the base plate, which is brought to 140° C. (280° F.) by induction heating so that the powder becomes plastic, and then is pressed in a die heated to 50° C. (120° F.).

(4143) Brit. 600,411 (1948). Imperial Chemical Industries Ltd., *Electric Condenser.* The condenser is made by firing a low-melting point silicate glass with interposed layers of an Ag powder paste.

(4144) Japan. 174,863 (1948). J. Sugano, *Alloy for Thermocouple.* The alloy, composed of 1-6% V, 1-10% Al, rest Fe, is used as one of the lead wires, and the other is made of pure W or Mo, instead of Pt.

(4145) U. S. 2,437,097 (1948). A. J. King (King Laboratories Inc.), *Getter.* The material comprises a support of a thin Ni sheet and a powdered material on the support composed of Al-Ba and NiO.

(4146) U. S. 2,437,205 (1948). L. H. Middleton and D. H. Stoltenberg, *Spark Plug.* A center electrode is positioned in a smooth bore of an insulator; both are held externally in a predetermined relation during the compacting of a body of metal powder between bore and electrode.

(4147) U. S. 2,438,732 (1948). P. D. Williams (Eitel-McCullough Inc), *Electron Tube Cathode.* The cathode consists of a metallic core, an outer layer of sintered ThO_2 and an intermediate layer of WC.

(4148) U. S. 2,442,163 (1948). D. F. Drieschman (Eitel-McCullough Inc.), *Cathode.* The cathode comprises spaced supports of refractory metal and a W filament secured to the supports by welding it with an alloy of Cb and Ta with 4-20% Ru.

(4149) U. S. 2,442,264 (1948). R. L. Campbell (Allen B. Du Mont Laboratories), *Variable Inductance.* The ends of the rods of Cu are anchored in two cylinders of insulating material; one of the cylinders contains microscopic segregated particles of Fe powder.

(4150) U. S. 2,442,287 (1948). B. J. Edwards (Pye Ltd.), *Reproducing X-Ray Images.* The device comprises a cathode ray tube, containing a mosaic screen of a plate of insulating material or a fine wire mesh coated with insulation and having small metallic particles inserted into the mesh, but insulated from the wire.

(4151) U. S. 2,443,542 (1948). R. S. Ohl (Bell Telephone Laboratories), *Light-Sensitive Electric Device.* A photoelectric cell is formed of a portion of a Si ingot, produced by fusing Si powder of high purity in a Si crucible.

(4152) U. S. 2,444,158 (1948). F. H. Driggs (Fansteel Metallurgical Corp.), *Thermionic Device and Getter Element.* Highly porous, self-supporting bodies, are prepared from mixtures of Al, B, Cr and U by powder metallurgy; they are effective for removing the residual gas from thermionic devices.

(4153) U. S. 2,446,237 (1948). G. F. Mueller (Fansteel Metallurgical Corp.), *Selenium Rectifier.* A supporting electrode with a layer of gray, crystalline Se is subjected to vapors of benzonitrile and a counter electrode is applied over the treated Se surface.

(4154) U. S. 2,446,465 (1948). S. S. Fry (Fansteel Metallurgical Corp.), *Selenium Rectifier.* A supporting electrode with a layer of Se has its surface subjected to vapors of benzildioxime at the decomposition temperature; a counter electrode is then applied.

(4155) U. S. 2,447,038 (1948). P. L. Spencer (Raytheon Manufacturing Co.), *Cathode Structure.* The structure comprises a core of Ni and a Ni gauze bound to the core by fused Ni powder, with an electron emissive coating deposited over the gauze.

(4156) U. S. 2,447,973 (1948). P. D. Williams (Eitel-McCullough Inc.), *Coated Anode for Electron Discharge Devices.* The anode comprises a metallic body with a surface layer of ZrC and uncombined Zr, bonded together and to the anode.

(4157) U. S. 2,449,786 (1948). G. H. Lockwood and D. F. Way (Westinghouse Electric Corp.), *Getter.* The material consists of a major portion of powdered Zr and Th, with a minor portion of degreased Al flakes as binder.

(4158) U. S. 2,450,982 (1948). W. J. O'Brien (E. F. Andrews), *Dynamoelectric Machine.* The machine is provided with a combined flux distributing and rotor supporting member, composed of Fe powder with a thermo-setting plastic binder, having the end portions of plastic material.

(4159) U. S. 2,457,487 (1948). A. L. Peacock and B. A. Jensen (Sylvania Electric Products Inc.), *Glow Relay.* A getter is composed of a mixture of powdered Al, Zn, Mg, Th.

(4160) Brit. 617,470 (1949). The M-O Valve Co. Ltd. and D. A. Wright, *Thermionic Cathodes.* Cathodes for magnetrons are coated with metal powder of a similar or lower work function than the base metal prior to forming the emissive layer, thus reducing the change of potential gradient through the layer.

(4161) Brit. 630,624 (1949). Comp. Générale De Télégraphie Sans Fils, *Cathodes for Thermionic Valves.* Indirectly heated cathodes are made by giving a filament an insulating coating of periclase or magnesite. The filament is embedded in Ni powder and the assembly is sintered and coated with alkaline earth metal oxides.

(4162) Brit. Appl. 5202/49 (1949). Western Electric Co. Inc., *Production of Germanium Elements for Use in an Electric Field.* A Ge block is obtained by reduction of the dioxide, and the metal is comminuted before processing into the block.

(4163) U. S. 2,458,213 (1949). C. P. Smith (Radio Corp. of America), *Control Grid for Gas Tubes.* It is claimed that by covering the surface of the control electrode of the tube with powdered Zr metal, shifting in grid potential is minimized. This may be due to the Zr forming an alloy with the Ba which is deposited on the electrode.

(4164) U. S. 2,459,282 (1949). T. G. McDougal (General Motors Corp.), *Resistor and Spark Plug Embodying Same.* The ceramic section of the electrode comprises a lower and upper seal and the intermediate portion, *i.e.*, the resistance element. The lower seal consists of 55 parts powdered Cu, 45 parts borosilicate glass and 3 parts of a binder.

(4165) U. S. 2,460,492 (1949). S. Cutler and N. Wiener (Hoffman Radio Corp.), *Loop Inductance Compensator.* In order to overcome undesirable changes in the properties of loop antenna arrangements a slab of molded powdered Fe is used.

(4166) U. S. 2,462,245 (1949). L. A. Wooten (Bell Telephone Laboratories), *Space Discharge Device.* The invention relates particularly to photoelectric tubes and has for an object the improvement of space discharge devices. Various Cs-producing mixtures are claimed; one mixture comprises finely divided and intimately mixed Cs_2CrO_4, Cr_2O_3, Cu_2O and Al.

(4167) U. S. 2,462,906 (1949). E. P. Sauerborn (Federal Telephone & Radio Corp.), *Manufacture of Metal Contact Rectifiers.* A method of manufacturing rectifier disks involves placing a layer of base plate metal powder in a mold, the powder consisting of an alloy of approximately 61% Sn and 39% Cd. A layer of vitreous Se powder is distributed on the base plate powder, and the powders are consolidated by pressure to form a coherent disk having a base plate layer and a semi-conducting layer.

(4168) U. S. 2,462,998 (1949). S. Ruben, *Primary Cell with Permanganate Depolarizer.* A primary cell comprises a Zn anode, a cathode comprising an intimate mixture of a permanganate Ag or Cu permanganate in solid state and a finely divided conducting material (*e.g.* powdered Ag), a porous spacer between anode and cathode and in contact therewith, and an alkaline electrolyte absorbed in the spacer.

(4169) U. S. 2,463,316 (1949). S. Ruben, *Alkaline Dry Cell with Permanganate Cathode.* The depolarizer composition is an intimate mixture of $KMnO_4$ and graphite so as to produce an electrically conductive cathode element; graphite is the preferred conductive material, but metals such as Fe, Ag, etc., may be used.

(4170) U. S. 2,464,874 (1949). R. Loosjes (Hartford National Bank & Trust Co.), *Method of Manufacturing an Oxide Cathode for an Electric Discharge Tube.* The method comprises applying to the cathode carrier a thin layer of alkaline earth metal (Ba), superposing a thin layer of Cu by vaporization, incorporating the carrier in a discharge device and heating in an O_2 atmosphere.

(4171) U. S. 2,472,189 (1949). H. Bienfait (Hartford National Bank & Trust Co.), *Thermionic Tube Having a Secondary-Emission Electrode.* A secondary-emissive electrode for a thermionic tube has a multiplicity of parts on its surface that consist of finely divided black particles of Ni. A secondary-emissive material covers the area of the electrode around the Ni particles. The black substance is used to improve the radiation of heat and thus maintain the temperature of the electrode at a low value.

(4172) U. S. 2,473,550 (1949). P. L. Spencer (Raytheon Mfg. Co.), *Directly Heated Cathode.* A directly heated cathode comprises a bare compressed body of ThO_2, a powdered refractory metal, such as a mixture of powdered W or Mo, and Co.

(4173) U. S. 2,475,281 (1949). E. J. Hanley (Hercules Powder Co.), *Delay Electric Initiator.* The ignition composition comprises powdered Se, a powdered metal such as Pb or Sn, an oxidizing material, and a flash producing material, such as powdered Mg.

(4174) U. S. 2,477,601 (1949). J. F. Hanson (Raytheon Mfg. Co.), *Directly Heated Cathode.* The directly-heated cathode comprises a cylindrical sleeve of powdered ThO_2 and Mo.

(4175) U. S. 2,481,539 (1949). S. Ruben, *Method of Making Depolarizer Units for Alkaline Primary Cells.* The method comprises compressing a predetermined amount of a depolarizer composition into a pellet, placing the pellet in a metal container and consolidating the depolarizer with the metal container by pressing. Finely divided graphite, C, Ag, or Fe may be added as a conductive material.

(4176) U. S. 2,485,069 (1949). J. H. Scaff and H. C. Theuerer (Bell Telephone Laboratories), *Translating Material of Silicon Base.* Rectifying elements for translating devices are made by casting an ingot from a quantity of Si in powdered form to which has been added a definite percentage of B for the purpose of controlling the electrical resistance of the cast material; the rectifier is shaped from the resulting Si-B ingot.

(4177) U. S. 2,486,436 (1949). J. Rothstein, *Contamination Control.* A grid for electron tubes, which is designed to lessen the concentration of contaminant on the outer surface, takes the form of a wire having an outer layer of metal sintered in the form of a wire, with a strand of Pd-Ag alloy incorporated at the center which is capable of alloying with Ba used as a getter material.

(4178) U. S. 2,486,530 (1949). L. G. Jenness, (The Linde Air Products Co.), *Manganate Type Contact Mass and Production Thereof.* Basically, the process comprises sintering together at a high temperature an intimate mixture of a substance selected from the group consisting of the oxide compounds of the alkali or alkaline earth metals with an oxide of Mn. in a lower state of oxidation than MnO_2.

(4179) U. S. 2,492,142 (1949). K. J. Germeshausen, *Electric System Embodying Cold-Cathode Gaseous Discharge Device.* A cathode electrode consists of 100 parts of W powder, 8 parts BaO_2 and ½ part Co powder by weight; the Co serves as a binder and may be replaced by Ni, Cu or any other suitable binder.

4. MAGNETIC MATERIALS AND PRODUCTS

A. Permanent Magnets

i. Iron-Base Alloys (Alnico-type)

(4180) Japan. 93,787 (1931). T. Mishima, *Magnetic Alloy.* The alloy contains 1-15% Al, 5-30% Ni, 1-5% Cr, less than 1% C, remainder Fe.

(4181) Brit. 392,656; 392,657 (1933). T. Mishima, *Alloy for Permanent Magnets.* The alloy contains 5-15% Al, 5-29.5% Ni, 1-4% Cr, 0.1-1.0% C, remainder Fe.

(4182) Brit. 392,658; 392,662 (1933). T. Mishima, *Alloy for Permanent Magnets.* The alloy contains Fe as chief component with 8.1-29.5% Ni and 5.1-20% Al.

(4183) U. S. 1,927,940 (1933). W. Köster (Vereinigte Stahlwerke A. G.), *Iron-Containing Alloys for Permanent Magnets.* A mixture of 2-80% Co, Fe, and traces of C and from 2 to 35% of W, Mo, Cr, Mn, Al, or Si, is heated and quenched.

(4184) U. S. 1,928,382 (1933). W. Köster (Vereinigte Stahlwerke A. G.), *Permanent Magnet.* A permanent magnet resistant to temperature changes consists of a ferromagnetic alloy subjected to precipitation hardening; the constituents are 15% W, 30% Co, remainder Fe.

(4185) French 767,923 (1934). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Permanent Magnets.* A permanent magnet composition consists of 60-70% Fe, 6-15% Al and 20-30% Ni.

(4186) Austrian 140,126 (1935). Deutsche Edelstahlwerke A. G., *Production of Magnets for Loud Speakers.* The pressing and sintering of Al-Ni-Fe and permanent magnet pole pieces occurs in the same operation.

(4187) Japan. 110,203 (1935). K. Honda, *Permanent Magnet.* The alloy consists of 10.1-40% Ni, 8.1-40% Ti, less than 50% Co, and remainder Fe.

(4188) French 799,798 (1936). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Sintered Permanent Magnets.* Al is pre-alloyed with Fe, Ni or Co powder, crushed, and then all powders are mixed, pressed into desired shapes and sintered.

(4189) U. S. 2,027,994; 2,027,995; 2,027,996; 2,027,997; 2,027,998; 2,027,999; 2,028,000 (1936). T. Mishima, *Permanent Magnets Containing Ni-Al-Mn.* Specific compositions contain 5-40% Ni, 7-20% Al, 0.5-10% Mn, plus 1.5% C, balance Fe. V, Cr, Co may also be added.

(4190) U. S. 2,048,222 (1936). A. Rehmann (Deutsche Edelstahlwerke A. G.), *Magnets Made from Metal Powders.* Finely powdered metals; such as Fe containing Co, W, Cr, Mo and C are compressed in a mold and sintered by heating and simultaneous compression in a furnace.

(4191) U. S. 2,064,773 (1936). H. Vogt (Ferrocart Corp.), *Magnet for Loud Speakers.* The magnet is produced by sintering powdered W and Fe and has cores and pole pieces.

(4192) Brit. 464,632 (1937). British Thomson-Houston Co. Ltd., *Permanent Magnets.* The magnets are formed of ferrous metal powder with a binding substance, which is a non-magnetic metal powder having a melting point lower than that of Fe.

(4193) U. S. 2,082,041 (1937). C. S. Williams (Westinghouse Electric & Mfg. Co.), *Production of Permanent Magnets.* The process comprises quenching ferrous magnetic material from 1100° C. (2010° F.) aging at 700° C. (1290° F.) to homogenize it, reheating above 1100° C. (2010° F.) and quenching, followed by aging at 650° C. (1200° F.).

(4194) U. S. 2,087,336 (1937). K. S. Seljesaeter (Western Electric Co.), *Permanent Magnet Alloy.* An alloy for permanent magnets is produced by heating a binary alloy of 5% Ti with balance Fe to a temperature below the melting point to cause the Ti to dissolve in the Fe.

(4195) U. S. 2,105,652; 2,105,653 (1938). K. Honda, *Steel for Permanent Magnet.* An alloy comprising 24% Ni, 18% Ti, and remainder Fe, is characterized by a coercive force of 300 gausses.

(4196) U. S. 2,105,654; 2,105,655; 2,105,656; 2,105,657; 2,105,658 (1938). K. Honda, *Permanent Magnet.* An alloy contains 11% Ni, 10% Sn, 20% Co, 0.1-20% Cu and remainder Fe and is characterized by a coercive force of 250 gausses or more.

(4197) U. S. 2,118,285 (1938). W. Zumbusch (Deutsche Edelstahlwerke A. G.), *Permanent Magnet.* The magnet consists of a mixture of a number of different permanent magnetic alloys which are produced from powders; the difference between

the coercive forces of the different alloys is not greater than 20%.

(4198) Brit. 501,672 (1939). N. V. Philips' Gloeilampenfabrieken, *Alloys for Permanent Magnets.* Permanent magnet is composed of 22-32% Ni, 1½-15% Co, 0.5-7% Ti, 5-12% Al, balance Fe.

(4199) Brit. 510,766 (1939). Metallgesellschaft A. G., *Permanent Magnets.* Sintered Alnico alloy is produced by heat treatment prior to pressing above the melting point of Al.

(4200) Brit. 512,375 (1939). Metallgesellschaft A. G., *Sintered Permanent Magnets.* Permanent magnets are composed of an Fe-Ni-Al alloy of which 60% of the Fe powder passes through a sieve of 10000 mesh/in2, and the grain size of the Ni powder and the balance of the Fe powder varies as much as possible.

(4201) French 843,536 (1939). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Sintered Permanent Magnet.* The magnet material consists of 8-13% Al, 14-25% Ni, 2-18% Co, 2-16% Cu, and remainder Fe.

(4202) French 845,650 (1939). Metallgesellschaft A. G., *Sintered Permanent Magnets.* The different metal powders used for Fe-Ni-Al magnets are preheated individually to 700-900° C. (1290-1650° F.) before starting production.

(4203) German 671,048 (1939). Robert Bosch G.m.b.H., *Iron or Steel Alloy for Permanent Magnets.* The alloy consists of 7-40% Ni, 3-20% Al, remainder Fe; the Fe content must be larger than either one of the other ingredients.

(4204) German 673,877 (1939). Allgemeine Elektrizitäts Gesellschaft, *Permanent Magnets.* The magnets consist of 47% Fe, 30% W or Mo, and 23% Co, and are pressed and sintered in reducing atmosphere at 1500° C. (2730° F.), and annealed at 700° C. (1290° F.).

(4205) German 679,594 (1939). Allgemeine Elektrizitäts Gesellschaft, *Permanent Magnets.* The production of permanent magnets comprises first making a prealloy from Al and Fe, pulverizing the alloy, mixing with other metal powders, pressing and sintering.

(4206) U. S. 2,167,240 (1939). F. R. Hensel (P. R. Mallory & Co. Inc.), *Material for Permanent Magnets.* The material consists of 16% Ni, 11% Ti, 28% Co and remainder Fe powder, mixed with a decomposing hydride such as CaH_2.

(4207) Brit. 519,183 (1940). The British Thomson-Houston Co. Ltd., *Alloys for Permanent Magnets.* Sintered alloys containing oxidizable metal, such as Al, are sintered under H_2 and cooled; *e.g.*, 5-20% Al, 10-45% Ni or Co, remainder Fe.

(4208) Brit. 527,202 (1940). Electrical Research Products Inc., *Permanent Magnet Alloys.* Alloys containing 30-52% Fe, 36-62% Co, and 6-16% V are heated to 800-1300° C. (1470-2370° F.), cooled rapidly and then baked for several hours to permit precipitation hardening.

(4209) German 699,295 (1940). Deutsche Edelstahlwerke A. G. and W. Rohland, *Permanent Magnet.* The alloy consists of 9-38% Ni, 1-14% Ti, 0.5-11% Cb or Ta, 0-1.8% Si, 0.4% Co, balance Fe.

(4210) Italian 384,153 (1940). Robert Bosch G.m.b.H., *Process for the Manufacture of Permanent Magnets by Sintering.* A process for the manufacture of permanent magnets by sintering is characterized in that the ferromagnetic powder is compacted and thereafter sintered with the addition of a metallic binder material.

(4211) U. S. 2,192,741 (1940). G. H. Howe (General Electric Co.), *Sintered Alloys Suitable for Permanent Magnets.* A magnetic alloy comprising Fe, Al and Ni or Co is manufactured in the following manner: the readily oxidizable metal and one other ingredient are cast, pulverized, and pressed and sintered with the other ingredients; the product is cooled suddenly to effect solution of the ingredients, and then reheated to effect precipitation hardening.

(4212) U. S. 2,192,743 (1940). G. H. Howe (General Electric Co.), *Sintered Permanent Magnets.* Alloys of high transverse strength are composed of 5-20% Al, 10-45% of Ni or Co, balance Fe.

(4213) U. S. 2,192,744 (1940). G. H. Howe (General Electric Co.), *Sintered Permanent Magnet.* Alloys of high transverse strength are composed of 14-25% Ni, 8-13% Al, 2-18% Co, 2-16% Cu, balance Fe.

(4214) U. S. 2,205,611 (1940). G. Wassermann (American Lurgi Corp.), *Production of Permanent Magnets.* A permanent magnet alloy containing Fe, Ni and Al is produced by first preparing a mixture of two of the powders, pressing and sintering it at a temperature between 1200° C. (2200° F.) and the fusing point of the mixture; then heat treating the prealloy between 650-900° C. (1200-1650° F.) and again pulverizing it. The third powder is then added, the mixture is pressed and finally sintered.

(4215) French 868,451 (1941). Robert Bosch G.m.b.H., *Permanent Magnets.* The alloy consists of 22.5% Ni, 10% Al, 13% Co, 5% Cu, remainder Fe; the Al is introduced in form of an alloy with Fe.

(4216) German 702,770 (1941). W. Zumbusch (Deutsche Edelstahl A. G.), *Permanent Magnets.* The alloys consist of 0.65-1.6% C, 1.6-2.5% Si, 2.0-10.0% Cr; 6.0-40% Co and 3.0-8.0% W, and Fe with the usual additions of Mn, P and S comprise the remainder; the alloy may also contain Ti up to 1.5% and Cu up to 3%.

(4217) German 706,902 (1941). M. Baermann and Dynamit A. G. vorm. Alfred Nobel & Co., *Permanent Magnets.* The magnets are made of powdered magnetic steels, especially Ni-Al steel and a binder which is magnetic. The mixture is cold pressed and then heat-treated at 550-650° C. (1020-1200° F.); the powders are magnetized before they are pressed.

(4218) U. S. 2,239,144 (1941). R. S. Dean and C. W. Davis (Chicago Development Co.), *Permanent Magnets.* The production process comprises dispersing magnetic material, *e.g.* Fe, with or without additions of other metals, in Hg, removing the Hg and compacting the mass.

(4219) U. S. 2,245,477 (1941). G. B. Jonas, *Permanent Magnets Suitable for Specified Heat Treatment.* The alloys consist of Fe plus Ni, Co, Ti and Al.

(4220) U. S. 2,264,038 (1941). G. H. Howe (General Electric Co.), *Alloys for Permanent Magnets.* The alloys contain 30-36% Co, 16-25% Ni, 6-12% Ti and Al and Fe as balance.

(4221) U. S. 2,293,240 (1942). P. Brauburger (Robert Bosch G.m.b.H.), *Permanent Magnet.* An alloy of Fe-Ni-Al type is produced whose magnetic properties in a preferred direction exceed those in a direction extending transversely thereto.

(4222) U. S. 2,295,082 (1942). G. B. Jonas, *Permanent Magnets.* Permanent magnets formed of Fe alloy contain about 16-30% Co, 12-20% Ni, and 6-11% Al.

(4223) U. S. 2,301,366 (1942). H. Bumm and H. G. Müller, *Method of Increasing the Temperature of the Beginning of Recrystallization in Metals and Alloys.* A permanent magnet consists of a base alloy of Fe and Ni, and contains more Fe than Ni; it has a recrystallization temperature below 500° C. (930° F.). This alloy is mixed with Cu in a percentage within the miscibility gap to raise the recrystallization temperature.

(4224) Belgian 450,635 (1943). Deutsche Edelstahlwerke A. G., *Permanent Magnets.* A Fe-Al-Ni-Co alloy is pressed and heated to 1200° C. (2190° F.), followed by cooling in compressed air and annealing.

(4225) U. S. 2,323,944 (1943). J. L. Snoek, *Magnetic Materials, such as Ni-Al-Fe Alloys for Permanent Magnets.* A method for improving the magnetic properties of an alloy hardenable by dispersion, comprises cooling the body from 1000° C. (1830° F.) by subjecting it to a temperature gradient in a given direction and maintaining the temperature gradient during 1000-700° C. (1830-1290° F.); the body is then magnetized in a direction corresponding to the direction of the temperature gradient.

(4226) German 747,104 (1944). Siemens & Halske A. G., *Production of Alloys for Permanent Magnets.* In the production of an Fe-base alloy the oxides or hydroxides of the metals are jointly reduced, powdered, pressed and sintered to produce a homogeneous alloy, *e.g.* Fe-Co-W, Fe-Co-Mo, Fe-Ni-Cu or Fe-Pt.

(4227) U. S. 2,347,817 (1944). O. J. Finch and J. H. White (Bell Telephone Laboratories), *Permanent Magnet.* An alloy of 50.4% Fe, 19.0% Ni, 9.5% Al, 11.5% Co, 4.8% Cu, and 4.8% V may be sintered or cast, and heated to 1200° C. (2190° F.) and cooled slowly in Silocel, a finely divided infusorial earth consisting largely of SiO_2; the temperature is then raised to 650° C. (1200° F.) and maintained for 5 hours followed by slow cooling.

(4228) Brit. 569,718 (1945). Swift, Levick & Sons Ltd. and G. Horsburgh, *Permanent Magnet Material.* Finely ground Fe, Al, Ni and Co are mixed, pressed, and sintered above 1150° C. (2100° F.) and below the melting point of the mixture in an inert atmosphere. The product is then subjected to the action of a magnetic field while cooling.

(4229) Brit. 575,102 (1946). International Nickel Co., *Permanent Magnets.* Permanent magnets are made by hot-working a cast or sintered alloy containing 4-9.5% Al, 1-3% Ti, 15-30% Ni, 2-15% Co, balance Fe.

(4230) U. S. 2,427,018 (1947). E. A. Nesbitt (Bell Telephone Laboratories), *Permanent Magnets.* Permanent magnets of superior quality are produced when 1-4% V, 13-24% Mo are alloyed with Fe, heated to 1300° C. (2370° F.), quenched in oil and drawn for one hour at 675° C. (1250° F.).

(4231) Brit. 600,829 (1948). American Electro Metal Corp., *Sintered Shaped Bodies.* Alnico-type permanent magnets are deoxidized by including Mo, W, or Re into the mixture, which form oxides volatile at 1000° C. (1830° F.), 1200° C. (2190° F.), and 450° C. (840° F.), respectively, and escape before the onset of shrinkage.

(4232) U. S. 2,441,588 (1948). E. A. Nesbitt (Bell Telephone Laboratories), *Magnetic Material.* A composition used for permanent magnets consists of 78-82% Fe, 14-18% Mn and 3-5% V.

(4233) U. S. 2,442,219 (1948). J. K. Stanley (Westinghouse Electric Corp.), *Magnetic Alloy.* A magnetic alloy consists of 35.5% Co, 0.30-0.55% Cr, less than 0.005% C, and balance Fe.

(4234) U. S. 2,443,636 (1948). E. A. Nesbitt (Bell Telephone Laboratories), *Magnetic Material.* A material used for permanent magnets consists of 49-72% Fe, 4-21% Co, 18-22% Mn, and 4-12% V.

(4235) Austrian 162,871 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Permanent Magnets.* During sintering, the Fe-base Co-containing permanent magnet material is exposed to a strong magnetic field, whereafter cooling with regulated speed occurs in another magnetic field.

(4236) Austrian 162,894 (1949). Gebr. Böhler & Co. A. G., *Production of Permanent Magnets.* A mixture of Fe-Ni-Al-Co is sintered under pressure and simultaneously heat treated in a magnetic field; the time for treatment in the magnetic field is less than the time for sintering.

(4237) Brit. 613,825 (1949). Assoc. Des Ouvriers En Instruments De Précision, *Permanent Magnets.* 80% Alnico powder and 20% soft Fe powder are cold-pressed; 2-3% synthetic resin may be added. Die wear is reduced by linings of soft Fe sheet, which are removed before or after annealing.

(4238) Brit. 615,941 (1949). The Indiana Steel Products Co., *Making Permanently Magnetizable Material.* The pressings of powder prepared from Fe-Al alloys may be heated in oil at 125° C. (438° F.) to drive off residual moisture.

(4239) Brit. Appl. 3439/49 (1949). The British Thomson-Houston Co. Ltd., *Sintered Permanent Magnets.* The alloys consist of 8.5% Al, 1% Ti, 25% Co, 3% Cu, 14% Ni, balance Fe; the Ti is included as a 70-30 Ti-Ni alloy.

(4240) Brit. Appl. 8774/49 (1949). The British Thomson-Houston Co. Ltd., *Sintered Anisotropic Alnico Magnets.* A composition of 8.5% Al, 0.5% Zr, 25% Co, 3.25% Cu, 14% Ni, and balance Fe is used for magnets, and anisotropy is obtained by sintering and cooling in a magnetic field.

ii. Other Types of Alloys (Copper-Base)

(4241) U. S. 2,170,047 (1939). W. Dannöhl and H. Neumann (Siemens & Halske A. G.), *Copper-Cobalt-Nickel Alloy Permanent Magnet.* A mixture of 20-85% Cu, 5-70% Co, 10-50% Ni, and up to 2% Mn is magnetized by heating and quenching, and results in a coercive force of 100 oerstedts.

(4242) U. S. 2,184,769 (1939). P. P. Alexander (Metal Hydrides Inc.), *Zirconium*

Magnetic Alloy. A powdered alloy containing 5-40% Zr and Ni, Fe or Co is subjected to a temperature of not less than 345° C. (650° F.) and not more than 800° C. (1470° F.) to form a permanent magnet.

(4243) German 700,600 (1940). Siemens & Halske A. G. and A. Büchner, *Permanent Magnets.* Copper-base alloys containing 15-40% Ni, 5-30% Fe and also Co and/or Be are sintered, quenched and annealed, at 550-650° C. (1020-1200° F.), and then cold-rolled.

(4244) German 701,528 (1940). Siemens & Halske A. G., H. Newman, H. Reinboth and A. Büchner, *Permanent Magnets.* Addition to German 700,600 (No. 4243). The composition is adjusted to 15-25% Ni, 10-25% Fe, 50-75% Cu.

(4245) U. S. 2,196,824 (1940). O. Dahl, J. Pfaffenberger and P. Melchior (General Electric Co.), *Permanent Magnet Consisting of Copper, Iron and Nickel.* A precipitation hardenable sintered permanent magnet is composed of 30-75% Cu, 5-55% Fe, and 15-50% Ni.

(4246) U. S. 2,347,543 (1944). W. Dannöhl and H. Neumann (Siemens & Halske A. G.), *Alloys for Permanent Magnets.* The alloy consists of 5-25% Fe, 15-35% Ni, 5-40% Co; the balance consists of 30-60% Cu and minor amounts of customary additions and impurities; the mixture is magnetized up to a coercive force of 100 oerstedts.

(4247) U. S. 2,428,205 (1947). H. Dannöhl and H. Neumann, *Permanent Magnet Alloy.* A permanent magnet alloy consists of at least 55% Cu, 5-10% Ag, with the remainder a ferromagnetic metal.

iii. Oxide-, Pressed and Molded Magnets

(4248) U. S. 1,976,230 (1934). Y. Kato and T. Takeshi (Mitsubishi Denki K. K.), *Permanent Magnets.* A permanent magnet is composed of oxides of Fe, Cu, and of a metal selected from Ni, Cu, Cr, or W.

(4249) U. S. 1,997,193 (1935). Y. Kato and T. Takeshi (Mitsubishi Denki K. K.), *Permanent Magnet.* A permanent magnet is composed of agglomerated particles of finely comminuted oxides of Fe and Co.

(4250) German 656,966 (1938). Dynamit A. G., vorm. Alfred Nobel & Co. and M. Baermann, Jr., *Production of Permanent Magnets.* The ferromagnetic material is mixed with a sufficient quantity of a binder so that it can be cold pressed without sintering and then be magnetized.

(4251) German 683,642 (1939). Dynamit A. G., vorm. Alfred Nobel & Co. and M. Baermann, Jr., *Permanent Magnets.* Addition to German 656,966 (No. 4250). To the mixture of permanent magnetic powder and binder is added ferromagnetic materials, whose permeability diminishes with rising temperature.

(4252) U. S. 2,188,091 (1940). M. Baermann, Jr., *Permanent Magnets.* The manufacturing process comprises agglomerating a mixture of magnetic powders with a binder by pressure and in a magnetic field, at a temperature at which the material retains its magnetic qualities, and finishing by pressing and magnetizing the body in the same direction as effected by the magnetic field.

(4253) German 708,101 (1941). Dynamit A. G., vorm. Alfred Nobel & Co. and M. Baermann, Jr., *Production of Permanent Magnets.* The mixture of magnetizable metal and binder is subjected to a magnetic field during mixing and pressing.

(4254) German 723,872 (1942). Mitsubishi Denki K. K., *Permanent Magnet.* The magnet is made by sintering small particles of Fe_2O_3, FeO or magnetite and Co oxide.

(4255) Canadian 441,403 (1944). Western Electric Co. and A. F. Bandur, *Magnetic Body.* Annealed Fe_3O_4 is mixed in 100:35 proportions with a water soluble soap of glycerol-phthalate resin and casein and heated for 1½ hrs. at 165° C. (330° F.).

(4256) Brit. Appl. 32901/46 (1946). Soc. D'Électro Chimie, D'Électro Métallurgie et Aciéries Electriques D'Ugine, *Magnetic Alloy Powders.* Very fine and pure mag-

netic alloy powders, *e.g.* Fe-Ni, Fe-Ni-Cu or Fe-Co are made by heating the formates or oxalates of the metals in H_2 at 600° C. (1110° F.). Ammoniacal solutions of Ni-or Fe-sulfates are reduced with an excess of oxalic acid. Powders are pressed into shape but not sintered.

(4257) Brit. 590,392 (1947). Soc. D'Electro-Chimie, D'Électro-Métallurgie et Acieries Électriques D'Ugine, *Manufacture of Magnets.* A method of making magnets comprises pressing (without sintering) magnetic powders of colloidal size (0.1 μ). The powders are produced by the following methods: Fe or Ni powder by the Raney method; Fe, Ni, Co powder by decomposition of oxalates, hydroxides or carbonates; colloidal carbonyl powders by bubbling vapor through oil at 300° C. (570° F.); colloidal carbonyl Fe by bubbling H_2 through Fe carbonyl at 50° C. (122° F.).

(4258) Brit. 594,474 (1947). The Plessey Co. Ltd. and M. W. G. Chitty, *Magnetizable Materials.* Co-ferrite used for permanent magnets is prepared by heating the double oxalates in a closed container at 450° C. (840° F.) for 1 hr, and then in air for 5 min., during which period the temperature is raised to 600° C. (1110° F.). Sound-recording strips are made by incorporating ferrite powder in cellulose acetate.

(4259) Brit. 594,681 (1947). Soc. D'Électro Chimie, D'Électro Métallurgie et Acieries Électriques d'Ugine, *Preparation of Powders for Permanent Magnets.* Magnets made from colloidal Fe according to Brit. 590,392 (No. 4257) are improved when a small amount of CaO, MgO or Al_2O_3 is incorporated in the powders.

(4260) Brit. 596,875 (1948). Soc. D'Électro-Chimie, D'Électro-Métallurgie et Des Aciéries Électriques d'Ugine, *Manufacture of Permanent Magnets.* The magnets are produced from Fe and Co formates likely to be decomposed by heat at a temperature lower than 600° C. (1110° F.) in a neutral or oxidizing atmosphere, to give the pressed powder magnets qualities which are higher than those of oxide magnets.

(4261) Brit. Appl. 4005/48 (1948). Indiana Steel Products Co., *Making Magnetizable Material.* An Fe-Al alloy is heat treated first at 1100° C. (2010° F.), air cooled and ground to -100 mesh. The powder is poured into caustic soda solution at its boiling temperature and the leach solution is decanted and residue washed with NaOH solution. The material has an oxyferrite matrix with Fe_3O_4 present.

(4262) Canadian 450,776 (1948). Western Electric Co. Inc., *Treatment of Finely Divided Magnetic Material.* Ferrosoferric oxide with a molecular ratio of Fe_2O_3/FeO of 1.4:1.55 and a tap density of 0.8-0.85 is heated to 980-1020° C. (1800-1870° F.) in an inert atmosphere for ½-5 hours.

(4263) French 934,794 (1948). Indiana Steel Products Co., *Making Permanent Magnet Material.* Recording tape is produced from a magnetic oxide powder prepared from an Fe-Al alloy, which is heat treated at 1100° C. (2010° F.) and air cooled; the pieces are ground.

(4264) Brit. 610,514 (1949). Soc. D'Électro-Chimie, D'Électro-Métallurgie et Aciéries Électriques D'Ugine, *Manufacture of Iron Powder.* Variation of Brit. 590,392 (No. 4257). Fe-formate is decomposed and reduced at 550° C. (1020° F.) in H_2, pressed at 60 tsi to produce a compact with a density of 7.0, which is highly suitable for small magnetic or structural parts; high density pressings can be sintered at low temperature.

(4265) Brit. 612,879 (1949). Soc. D'Électro Chimie, D'Électro Métallurgie et Aciéries Électriques D'Ugine, *Permanent Magnets.* The mechanical strength of permanent magnets pressed from colloidal powders is increased by heating them in moist H_2 for 1 hour between 300-450° C. (600-840° F.).

(4266) U. S. 2,463,413 (1949). L. Néel (Soc. d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine), *Manufacture of Permanent Oxide Magnets.* A method of making permanent magnets comprises simultaneously crystallizing Fe and Co salts from a solution containing both. The salts are decomposed into oxides by heating at a temperature below 600° C. (1110° F.). They are then agglomerated to the desired shape and reheated in a magnetic field.

iv. Combination Magnet Assemblies (Permanent and Soft Magnets)

(4267) Brit. 576,754 (1946). The British Thomson-Houston Co. Ltd., *Permanent Magnets.* The production process consists of forming a composite body of a sintered alloy of high magnetic retentivity and of a material with less retentivity.

(4268) Austrian 162,210 (1949). Metallwerk Plansee G.m.b.H., *Permanent Magnet for Electric Machines.* The magnet consists of a sintered ring with permanent magnetic segments and interpositions of soft magnetic Fe, fixed interchangeably at the magnetic poles.

(4269) Austrian 162,345 (1949). Metallwerk Plansee G.m.b.H., *Sintered Permanent Magnet.* The sintered permanent magnet and the pole shoes are connected by a thin layer of soft Fe to produce a joint.

(4270) Austrian 162,506 (1949). Metallwerk Plansee G.m.b.H., *Method for Production of Permanent Magnets.* The permanent magnet compact is formed so that the magnetic gap ("interferricum") is closed by soft Fe, which is machined out after sintering and thermal treatment.

(4271) Austrian 162,507 (1949). Metallwerk Plansee G.m.b.H., *Armature for Electric Machines.* The composite magnetic body consists of one sintered permanent magnet piece to which soft magnetic pole shoes are sintered.

(4272) Austrian 162,870 (1949). Metallwerk Plansee G.m.b.H., *Iron Alloy for Sintered Conductor Pieces in Magnets.* The conductor pieces contain, besides Fe, 7-10% Fe-Al or Fe-Si-Al, which becomes fluid below the sintering temperature, at which the pieces are joined with the magnet of Fe-Ni-Al or Fe-Co-Ti.

(4273) Austrian 163,784 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Permanent Magnets.* The individually formed bodies of magnetic powder and of soft Fe for pole shoes are presintered, machined, then pressed together and sintered to a coherent body.

(4274) U. S. 2,459,195 (1949). P. L. Spencer (Raytheon Mfg. Co.), *Electron Discharge Device.* An electron discharge device of the magnetron type is enclosed in an envelope in which an anode and a cathode are supported in spaced relation. The magnet pole pieces extend into the envelope in axial alignment with the cathode. Each pole piece consists of an electrically conductive, readily malleable, thin-walled shell having compacted therein finely divided magnetic material, such as Alnico.

B. Soft Magnetic Parts

i. Soft Iron-Base Magnets (for D. C. and A. C.)

(4275) Brit. 383,691 (1932). I. G. Farbenindustrie A. G., *Improvement in the Manufacture and Production of Magnetic Materials.* A magnetic material is prepared by interdiffusing at least two Fe alloys, such as Fe-Ni which are prepared from carbonyl powder.

(4276) Brit. 399,318 (1933). Deutsche Edelstahlwerke A. G., *Alloys.* Pole pieces of magnets are made by induction heating powdered metal to the sintering temperature by means of a current in a coil of Cu tubing. The alloy contains 5-50% Co, 1-20% W, 5% Cr, 15% Mo, 0.5-7% C, remainder Fe.

(4277) German 597,534 (1934). I. G. Farbenindustrie A. G., *Magnetic Material.* The material is produced by decomposition of carbonyl compounds of metal powders, *e.g.* Ni and Fe. The powders are then pressed and sintered.

(4278) German 632,946 (1936). Deutsche Edelstahlwerke A. G., *Production of Pole Shoes for Permanent Magnets.* Fe base composition powders are pressed and sintered to the finished shape.

(4279) **Brit. 461,948** (1937). Siemens & Halske A. G., *Sintered Magnetizable Material.* Mixtures of oxides of Fe and Ni are reduced and sintered, and the product is subjected to one or more cold workings.

(4280) **U. S. 2,075,283** (1937). A.Heinzel and F. Duftschmid (I. G. Farbenindustrie A. G.), *Production of Magnetizable Alloy.* Sintered Fe and Ni alloys prepared from carbonyl powders are subjected to special working and annealing treatments to obtain optimum magnetic properties.

(4281) **Brit. 495,668** (1938). General Electric Co., Ltd. and G. H. S. Price, *Magnetic Alloy.* The high density alloy consists of 88% W, 5-6% Ni, 2-4% Cu and 2-5% Fe; the powder mixture is pressed and sintered. The product has a permeability greater than 2.

(4282) **U. S. 2,206,537** (1940). G. H. S. Price (General Electric Co. Ltd.), *Magnetic Alloy. Cf.:* Brit. 495,668 (No. 4281).

(4283) **French 869,559** (1942). E. Plantrow, *Magnetic Conductor.* Powdered Fe_3O_4 is mixed with an organic binder or with Zn, Al, or bronze, pressed and sintered in a reducing atmosphere.

(4284) **German 737,371** (1943). Heraeus-Vacuumschmelze A. G. and W. Rohn, *Iron-Nickel Sintered Alloys.* Magnetic alloys are made by sintering Fe-Ni powders which are prepared from carbonyls together with additions of powdered Cu, Co, Mn, Cr, Si, Ag, or Mo. The sintered products are then rolled and drawn.

(4285) **German 737,508** (1943). Deutsche Edelstahlwerke A. G. and W. Zumbusch, *Conductors for Permanent Magnets.* Sintered ferromagnetic conducting pieces, such as pole pieces which are to be attached to sintered permanent magnets of the Fe-Ni-Al alloy type (with or without Ti, Co and Cu) are made of Fe-W alloys containing 2-15% W and up to 18% Co.

(4286) **German 742,930** (1943). Heraeus-Vacuumschmelze A. G., *Treatment of Iron for Low Increase of Initial Permeability.* Initial permeability of carbonyl Fe is increased by only 15-20% with a change in field strength of 0.02-0.1 oersted by cold rolling to about 80% reduction, annealing at 600-700° C. (1110-1290° F.), coiling with further slight reduction, and annealing at 700-900°C. (1290-1650° F.).

(4287) **German 743,249** (1943). Fried. Krupp A. G., *Magnetic Conductors.* By mixing suitable ratios of magnetic alloy powders having Curie points covering the temperature range required, any temperature-magnetization curve can be obtained reproducibly. The powders should be fairly coarse, and only slightly sintered to avoid diffusion.

(4288) **German 748,069** (1944). Fried. Krupp A. G., *Magnetic Conductor.* Addition to German 743,249 (No. 4287). The pre-alloys, *e.g.*, three Fe-Ni alloys with different Ni contents are powdered, mixed with a synthetic resin and pressed.

(4289) **U. S. 2,343,354** (1944). F. Wolf and F. Si gmund (Lake Erie Chemical Co.), *Electric Motor.* Wedges or closures for slots or openings in stators or cores of electric motors are formed of magnetic metal powders.

(4290) **U. S. 2,361,752; 2,361,753** (1944). S. D. Eilenberger (Wolgen Co.), *Magnetic Recording Apparatus.* The apparatus has magnetic pole pieces made from plasticized magnetizable Fe powder.

(4291) **Brit. 609,689** (1949). American Electro Metal Corp., *Ferrous Bodies for Rotors.* A material for rotors is made from Fe powder and Si, mixed together with a deoxidizing agent, such as graphite, excess Si or ferrosilicon containing C. Deoxidation can be effected also by sintering in dry H_2 which also promotes a high degree of diffusion.

ii. High Frequency Cores and Pressed Powder Magnet Bodies

(4292) **U. S. 421,067** (1890). C. C. Currie (United Electric Improvement Co.), *Magnet Core.* Fe chips or filings are compacted with powdered asbestos to form a magnet core.

(4293) U. S. 476,816 (1892). G. Pfannkuche and A. Pfannkuche (Brush Electric Co.), *Magnetic Envelope.* A magnetic envelope for transformers is produced of paraffin-insulated Fe particles surrounding primary and secondary conductors.

(4294) U. S. 874,908 (1907). C. E. Fritts, *Magnetic Core.* The manufacture of a magnetic core consists of artificially converting the surfaces of small parts of Fe into a highly tenacious and impervious coating of magnetic oxide of Fe to form an insulation.

(4295) U. S. 1,142,034 (1915). P. F. Gerding, *Magnet Core.* The core has a tubular body divided into four sections by a cruciform magnetic conductor; the four sections are each filled with Fe filings.

(4296) U. S. 1,251,651 (1918). L. Espenschied (American Telephone & Telegraph Co.), *Magnetic Ring Core.* Increased permeability in an air gap for a magnetic ring core in telephone work is obtained by molding it from insulated Fe dust.

(4297) U. S. 1,274,952 (1918). J. B. Speed (Western Electric Co.), *Magnet Core.* A telephone circuit loading coil core is formed of soft 80 mesh Fe particles made by the hydrogen reduction process, which are coated with Fe_2O_3 and molded.

(4298) U. S. 1,286,965 (1918). G. W. Elmen (Bell Telephone Laboratories), *Magnet Core.* Improvement on U. S. 1,274,952 (No. 4297). Particles of electrolytic Fe are annealed, coated with Fe_2O_3 and pressed.

(4299) U. S. 1,292,206 (1919). J. C. Woodruff (Western Electric Co.), *Magnet Core.* Improvement on U. S. 1,274,952 (No. 4297). Fe particles are first coated with Pb or Zn and then insulated by coating with shellac.

(4300) U. S. 1,297,126; 1,297,127 (1919). G. W. Elmen (Bell Telephone Laboratories), *Magnet Core.* Improvement on U. S. 1,274,952 (No. 4297). Powdered electrolytic hard Fe is mixed with 5-10% soft Fe and coated with Zn.

(4301) German 336,507 (1921). E. Schroeder, *Production of Magnetic Cores.* A body for transformers is made of Fe particles and a bonding material and is characterized by the fact that the particles are oriented in a magnetic field.

(4302) German 341,678 (1921). Western Electric Co., *Production of Magnetic Cores.* Electrolytic Fe, annealed and oxidized, is pressed in a mold at a pressure sufficiently high that the particles will be pressed together above the linear elastic limit, to produce a core whose specific gravity is similar to that of the raw material.

(4303) U. S. 1,378,969 (1921). J. L. Milton (Western Electric Co.), *Magnet Core.* Cores made according to U. S. 1,286,965 (No. 4298) are treated by baking, demagnetizing and baking again.

(4304) U. S. 1,381,460 (1921). J. W. Harris (Western Electric Co.), *Magnet Core.* A magnet core of the type described in U. S. 1,274,952 (No. 4297) is improved by using annealed particles which are flattened into small flakes.

(4305) German 352,009 (1922). Bell Telephone Manufacturing Co., *Magnetic Core.* The addition of soft magnetic material to the hard magnetic basic material for bonding purposes also increases the permeability of the core.

(4306) German 364,451 (1922). Bell Telephone Manufacturing Co., *Magnetic Core.* Fe particles are plated with other metals, covered with an insulating film, and pressed.

(4307) U. S. 1,403,305 (1922). G. W. Elmen (Bell Telephone Laboratories), *Magnet Core.* A magnet core of the type described by U. S. 1,297,126 (No. 4300) is hardened by treating the magnetic Fe with a carbonizing agent.

(4308) U. S. 1,494,070 (1924). H. R. MacKnight, *Magnet Core.* A magnet core of powdered Fe is suspended in a fluid insulating compound.

(4309) U. S. 1,523,109 (1925). G. W. Elmen (Bell Telephone Laboratories), *Magnet Core.* Powdered Fe and Ni are heated to the alloying temperature; the sintered mass is then ground into alloy particles.

(4310) U. S. 1,609,745 (1926). C. G. Vawter (Electrad Inc.), *Magnetic Core.* The core is formed of a mixture of Fe dust and an insulating liquid binder and pressed to extract a part of the lacquer binder.

(4311) Brit. 269,511 (1927). J. W. Andrews and R. Gillis, *Material for Magnet Cores*. The cores consist of powdered Fe, Ni and an insulator of chromic acid, talc, waterglass etc.

(4312) U. S. 1,615,685 (1927). W. Ehlers (General Electric Co.), *Magnetic Core*. The press form may be filled with varied mixtures of finely divided insulating materials and magnetic particles, to achieve a uniform compression.

(4313) U. S. 1,618,818 (1927). W. Ehlers (General Electric Co.), *Induction Coil Core*. The core is made of a powdered magnetic material and a dry insulating material, pressed, and heated to a temperature sufficient to melt one ingredient.

(4314) U. S. 1,632,105 (1927). L. Zickrick (Western Electric Co.), *Magnetic Core Material and Method of Producing It*. The core is produced by alloying Sb with a magnetic material and reducing the resulting brittle product to a finely divided form.

(4315) U. S. 1,647,737; 1,647,738 (1927). V. E. Legg (Bell Telephone Laboratories), *Magnet Core*. Ni-Fe magnetic alloy particles have a spongy oxide coating formed on their surfaces, the pores of which are filled with powdered quartz.

(4316) U. S. 1,651,957; 1,651,958 (1927). H. H. Lowry (Bell Telephone Laboratories), *Magnetic Core*. Finely divided magnetic material is insulated with a mixture of Mg-borate and SiO_2, or with MgO and ZnO.

(4317) U. S. 1,669,642; 1,669,643 (1928). J. W. Andrews (Western Electric Co.), *Magnetic Core*. Magnetic particles are insulated by coating them with silicic acid and waterglass and then coating with silicic acid and Fe_2O_3.

(4318) U. S. 1,669,644; 1,669,645 (1928). J. W. Andrews (Western Electric Co.), *Magnetic Core*. The magnetic particles are insulated with Na-silicate, and bound with synthetic resin, or with Hg-nitrate.

(4319) U. S. 1,669,646 (1928). A. F. Bandur (Western Electric Co.), *Magnetic Cores*. Magnetic particles are insulated with a flux of boric acid and kaolin; the compressed cores are then impregnated with $Zn(OH)_2$.

(4320) U. S. 1,669,647; 1,669,648 (1928). A. F. Bandur (Western Electric Co.), *Magnetic Core*. The magnetic particles are treated with hydrated Al_2O_3 and boric acid and then given a secondary coating of kaolin, after which they are compressed and heat treated.

(4321) U. S. 1,669,658 (1928). G. W. Elmen (Bell Telephone Laboratories), *Magnetic Dust Core*. A magnetic dust core is heat treated after compression to restore the magnetic and electric properties lost during pressing.

(4322) U. S. 1,695,041 (1928). G. W. Elmen (Bell Telephone Laboratories), *Magnetic Dust Core*. Particles are given a spherical shape by spraying molten metal into water; the spherical form protects the coating of insulation.

(4323) U. S. 1,698,300 (1929). W. Ehlers (General Electric Co.), *Method of Manufacturing Cores*. Bodies of powdered magnetic material are pressed by applying pressure within a range over which the density remains substantially constant.

(4324) U. S. 1,703,287 (1929). J. W. Andrews (Western Electric Co.), *Magnetic Material*. An Fe-Ni alloy for dust cores is made brittle by partially oxidizing it while molten, solidifying and rolling it while hot until it is below the temperature of recrystallization; the material is then pulverized.

(4325) U. S. 1,714,683 (1929). H. H. Lowry (Bell Telephone Laboratories), *Magnetic Dust Core*. The particles of an alloy are mixed with hydrated SiO_2, the mixture is evaporated, formed into a core, and heat treated.

(4326) U. S. 1,715,543 (1929). G. W. Elmen (Bell Telephone Laboratories), *Magnetic Dust Core*. The core is produced from an alloy of Fe, Ni and Co which is reduced to powder.

(4327) U. S. 1,721,379 (1929). W. Ehlers (General Electric Co.), *Magnetic Dust Core*. The permeability of a dust core is increased by impregnating the pressed core with a colloidal solution of magnetic material.

(4328) U. S. 1,725,026 (1929). R. Swinne (Siemens & Halske A. G.), *Magnetic Dust Cores*. The cores are made of finely divided magnetic particles in the monocrystalline form.

(4329) U. S. 1,728,451 (1929). W. Smith, H. J. Garnett and J. Holden, *Magnetic Dust Core.* The core is produced from an alloy of powdered Fe, Cr and Si.

(4330) U. S. 1,733,592 (1929). F. J. Given (Bell Telephone Laboratories), *Magnetic Dust Core.* A permalloy dust having too low a content of one component is mixed with dust having an excessively high content of the same component, enabling formerly wasted dust to be used.

(4331) U. S. 1,739,052 (1929). J. H. White (Bell Telephone Laboratories), *Magnetic Cores.* An alloy of Ni and Fe is embrittled with S to make it easily reducible.

(4332) U. S. 1,741,751 (1929). J. Zueger (Landis & Gyr A. G.), *Magnet Core.* A meter driving magnet core is made of pulverized Fe.

(4333) Brit. 308,224 (1930). British Thomson-Houston Co. Ltd., *Magnetic Insulating Material.* The insulating pieces, used for cores, consist of fibrous material impregnated with a mixture of resin and powdered magnetic metal, and are consolidated under pressure and heat.

(4334) U. S. 1,747,854 (1930). R. M. Bozorth (Bell Telephone Laboratories), *Magnetic Dust Core.* Magnetic particles are first mixed with SiO_2 dust, heat treated and then separated from the SiO_2; the particles are then insulated and pressed.

(4335) U. S. 1,759,612 (1930). F. J. Given and J. R. Weeks (Bell Telephone Laboratories), *Magnetic Dust Core.* The magnetic particles are given a preannealing heat treatment.

(4336) U. S. 1,774,856 (1930). H. R. Van Deventer (Dubilier Condenser Corp.), *Magnetic Core.* A laminated magnetic core of paper is coated with a continuous layer of Fe dust.

(4337) U. S. 1,783,560; 1,783,561 (1930). K. Eisenmann and F. Bergmann (I. G. Farbenindustrie A. G.), *Magnetic Core.* Fe powder obtained from Fe carbonyl is mixed with Montan wax, or a resinous condensation product of urea, and pressed into magnetic cores.

(4338) U. S. 1,784,827 (1930). G. W. Elmen (Bell Telephone Laboratories), *Loading Coil.* The coil contains powdered and mixed particles of hard steel and an Fe-Ni alloy.

(4339) German 533,952 (1931). I. G. Farbenindustrie, A. Curs, L. Schlecht and C. Mueller, *Alloys for Magnetic Cores.* Alloys for magnetic cores are produced by mixing Fe powder produced from Fe carbonyl and Ni from Ni carbonyl, and sintering.

(4340) U. S. 1,787,606 (1931). J.H. White and V.E. Legg (Bell Telephone Laboratories), *Material for Magnetic Dust Core.* A high yield of dust is obtained from comminuting Ni-Fe-Cr alloys by incorporating 4% Cu.

(4341) U. S. 1,789,477 (1931). P. N. Roseby (Associated Telephone & Telegraph Co.), *Magnetic Dust Core.* The particles are coated with Fe phosphate and bound with a synthetic resin varnish.

(4342) U. S. 1,790,704 (1931). J. E. Harris (Bell Telephone Laboratories), *Material for Magnetic Dust Core.* The yield of dust is increased by adding up to 6% Sn, Bi or Pb to alloys of Fe-Ni or Fe-Ni-Co.

(4343) U. S. 1,795,639 (1931). J. C. Chaston (Western Electric Co.), *Magnetic Dust Core.* Insulated particles are compressed, conditioned in moist air and heat treated; the moisture causes the insulation to swell.

(4344) U. S. 1,809,042 (1931). G. A. Kelsall (Bell Telephone Laboratories), *Transformer Core.* The core is made from finely divided Ni-Fe alloys which are loosely packed in a container, rather than being compressed.

(4345) U. S. 1,818,070 (1931). H. Lathrop, (Bell Telephone Laboratories), *Magnetic Dust Core.* The particles are insulated and bound by talc and Na-silicate of a high silicate to soda ratio, obviating the use of chromic acid.

(4346) U. S. 1,818,596 (1931). P. Zimmermann (Western Electric Co.), *Magnetic Dust Core.* The particles are insulated by Zr-silicate alone or combined with kaolin.

(4347) U. S. 1,826,711 (1931). J. W. Andrews and R. Gillis (Western Electric Co.), *Magnetic Dust Core.* The Permalloy particles are insulated with a mixture of glue, soap and water.

(4348) U. S. 1,827,376 (1931). R. C. Shermund (Federal Telegraph Co.), *Magnetic Dust Core.* 10% of finely ground mica is reground with Fe dust and compressed.

(4349) U. S. 1,831,280 (1931). L. K. Wright, *Surgical Instrument.* A surgical instrument for extracting metallic chips from the body contains a sliding core member which is filled with magnetic Fe particles.

(4350) U. S. 1,832,937 (1931). E. Kramer (Hartstoff Metal A. G.), *Magnetic Dust Core.* The particles are insulated with finely disintegrated silk paper and shellac.

(4351) U. S. 1,838,831 (1931). E. Hocheim (I. G. Farbenindustrie A. G.), *Magnetic Iron Powder.* Magnetic Fe powder for cores of superior permeability is prepared by decomposing Fe carbonyl, and treating the powder in H_2 atmosphere.

(4352) Austrian 127,448 (1932). Hartstoff Metall A. G., *Production of Iron Powder for Magnetic Core.* The Fe or Fe alloy is fused and then worked to pieces of smaller dimensions which are subjected in a vacuum furnace to red heat, annealed in H_2 or N_2, cooled and pulverized.

(4353) Brit. 381,916 (1932). P. N. Roseby and Automatic Electric Co. Ltd., *Magnet Core Alloys From Powders.* Pressed powder particles of alloys containing 60-65% Fe, 20-25% Ni, and 20-15% Co are used for magnet cores.

(4354) U. S. 1,840,286 (1932). E. Hocheim (I. G. Farbenindustrie A. G.), *Magnetic Iron Powder for Cores.* The powder made according U. S. 1,838,831 (No. 4351) is compressed to form cores.

(4355) U. S. 1,840,352 (1932). G. W. Elmen (Bell Telephone Laboratories), *Magnetic Dust Core.* The core is annealed after compression in an atmosphere of N_2 or H_2.

(4356) U. S. 1,845,113 (1932). J. W. Andrews and R. Gillis (Western Electric Co.), *Magnetic Dust Core.* The Permalloy particles are annealed, and insulated with chromic acid, talc and waterglass, pressed and annealed again.

(4357) U. S. 1,845,144 (1932). R. Gillis (Western Electric Co.), *Magnetic Dust Core.* The core is annealed after compression at a temperature selected according to a formula which correlates the annealing temperature and the per cent of Ni in the alloy.

(4358) U. S. 1,850,181 (1932). P.N. Roseby (Automatic Telephone Mfg. Co. Ltd.), *Magnetic Dust Core.* The core is produced of short lengths of Ni-Fe wire to which powdered Fe is added as filler.

(4359) U. S. 1,853,924 (1932). C. D. Owens (Bell Telephone Laboratories), *Magnetic Dust Core.* The magnetic particles are mixed with insulating material in the presence of a volatile liquid.

(4360) U. S. 1,855,562 (1932). R. Swinne (Siemens & Halske A. G.), *Magnetic Dust Core.* The particles are insulated by adding to them a hydride of B or Si, decomposing the hydride to deposit a coating, and applying a chemical coating to form an oxide layer.

(4361) U. S. 1,859,201 (1932). C. P. Beath and H. M. Heinicke (Western Electric Co.), *Metal Powders for Magnetic Dust Cores.* A Ni alloy is made brittle by partially oxidizing its constituent metals while in the molten state and working the metals in the solid state while hot to produce a fine crystalline structure.

(4362) U. S. 1,863,325 (1932). L. G. Brazier and J. Urmston, *Magnetic Dust Core.* Osmotic kaolin is used as the insulating material for the particles.

(4363) U. S. 1,866,123 (1932). C. C. Neighbors (Western Electric Co.), *Magnetic Dust Core.* The particles are insulated with a non-hygroscopic residue of an evaporated mixture of an organic acid, sodium silicate and a ceramic binder.

(4364) U. S. 1,868,327 (1932). E. Kramer (Hametag A. G.), *Magnetic Dust Core.* The binder for the magnetic particles contains fine threads of asbestos.

(4365) U. S. 1,871,317 (1932). R. Gillis (Western Electric Co.), *Magnetic Dust Core.* The cores are compressed at 250,000 psi and annealed.

(4366) U. S. 1,878,589 (1932). G. C. Marris, G. R. Polgreen, and S. V. Williams, *Nickel-Iron Alloys.* A magnet core alloy powder is prepared by reducing powdered Ni and Fe oxides, sintering the mixed powders at a higher temperature than that of reduction, grinding, mixing with talc to prevent resintering, and final annealing.

(4367) U. S. 1,878,713 (1932). P. N. Roseby (Automatic Electric Co.), *Magnet Core.* Magnetic material is drawn to a wire which is flattened into a tape, cut to short length, insulated and compressed.

(4368) U. S. 1,879,361 (1932). F. Linnhoff (Ajax Electrothermic Co.), *Induction Furnace.* The induction coil is surrounded by a yoke of pressed magnetic Fe particles and ZnO.

(4369) U. S. 1,881,711 (1932). H. Lathrop (Bell Telephone Laboratories), *Magnetic Dust Core.* The particles are insulated by mixing them with kaolin and talc while dry, and adding a silica sol made with Na-silicate and Cr-acetate, then drying the mixture.

(4370) U. S. 1,887,380 (1932). W. J. Polydoroff (Johnson Laboratories), *Magnetic Core.* The core is manufactured by passing an electric current through the mass of insulated particles in the flux direction, thereby partially breaking down the insulation and bringing some particles into contact with each other.

(4371) German 588,381 (1933). International Standard Electric Corp., *Magnetic Alloys.* The alloys contain Fe, Ni and a metal of the Cr-group, with or without an addition of Co, and can be improved by adding 4% Cu. A typical composition is 78.5% Ni, 13.5% Fe, 4% Mo and 4% Cu.

(4372) U. S. 1,904,233 (1933). L. M. Hollingsworth (Bell Telephone Laboratories), *Magnetic Dust Core.* A preliminary annealing heat treatment is given to the magnetic particles after the insulation is applied.

(4373) U. S. 1,904,665 (1933). E. F. Northrup (Ajax Electrothermic Co.), *Electric Furnace Inductor Coil.* The coil is packed in an uncompressed mass of Fe filings and electrically resistant particles of ZrO_2 or ZnO to eliminate the stray field.

(4374) U. S. 1,915,386 (1933). W. C. Ellis and E. E. Schumacher (Bell Telephone Laboratories), *Finely Divided Magnetic Materials.* A Fe-Ni-Co alloy is pressed and sintered into a core material.

(4375) U. S. 1,919,806 (1933). H. Schulz (Siemens & Halske A. G.), *Magnetic Core.* Finely divided ferromagnetic particles are insulated by a CuO coating.

(4376) U. S. 1,932,639 (1933). P. N. Roseby (Automatic Electric Co.), *Magnetic Dust Core.* The particles are insulated by a coating of metallic fluorides.

(4377) Canadian 346,056 (1934). Western Electric Co., *Magnetic Powder.* The powder consists of a mixture of Fe, Ni, and Cr, Mo or W and is claimed to be useful for cores.

(4378) U. S. 1,943,115 (1934). W. C. Ellis (Bell Telephone Laboratories), *Magnetic Dust Core.* The Permalloy particles are coated with a mixture of colloidal clay, sodium silicate and milk of magnesia.

(4379) U. S. 1,948,308 (1934). C. C. Neighbors (Western Electric Co.), *Magnetic Dust Core.* The particles are insulated by applying coatings of a compound of tartaric acid, Na-silicate, water and insulating material and are dried between each coating to form a water insoluble film.

(4380) U. S. 1,954,102 (1934). P. N. Roseby (Automatic Electric Co. Ltd.), *Magnetic Dust Core.* The core is made of an alloy of 60-80% Ni and 40-20% Co.

(4381) U. S. 1,965,649 (1934). A. Jaumann (Siemens & Halske A. G.), *Transformer for Radio Frequency Circuits.* The annular mass core consists of Fe carbonyl particles insulated with a phenol condensation product.

(4382) U. S. 1,974,079 (1934). K. Maier (Siemens & Halske A. G.), *Magnetic Loading Coil Core.* The core is built up of layers of different magnetic materials which are coated with metal dust, to provide additional layers.

(4383) U. S. 1,981,468 (1934). P. N. Roseby (Automatic Electric Co. Ltd.), *Magnetic Dust Core.* The particles are insulated with varnish and calcined MgO and the mass is then subjected to the action of a magnetic field while being molded.

(4384) U. S. 1,982,689 (1934). W. J. Polydoroff (Johnson Laboratories), *Magnetic Core Material.* A compressed comminuted magnetic material contains individually insulated particles and a constant permeability for a band of radio frequencies.

(4385) U. S. 1,982,690 (1934). W. J. Polydoroff (Johnson Laboratories), *Selective Radio Circuit.* A high frequency inductance device for use in resonant circuits including at least one low-loss winding and a compressed comminuted magnetic core has insulated magnetic particles small enough to pass through a screen having 300 openings to the inch.

(4386) U. S. 1,991,143 (1935). W. Ehlers (Fried. Krupp A. G.), *Magnetic Bodies.* In radio-frequency magnetic bodies prepared from powders, a greater compression or density of the particles is produced by rolling them between sheets of steel until a strip is formed.

(4387) U. S. 1,994,534 (1935). F. E. Robinson (Radio Corp. of America), *Inductance Coil.* A "field-less" coil is constructed by winding a coil and filling it with a mixture of Fe dust and latex, after which the coil is vulcanized.

(4388) U. S. 2,006,987 (1935). F. Duftschmid (I. G. Farbenindustrie A. G.), *Magnetic Material for Communication Articles, such as Cores.* Magnetic material is made from a mixture of 41% finely divided Ni and 59% Fe, by heating the mixture for 4 hours to 1100° C. (2000° F.), rolling the mass and annealing for 3 hours at 750° C. (1380° F.).

(4389) U. S. 2,011,697; 2,011,698 (1935). H. Vogt (Ferrocart Corp.), *High Frequency Magnetic Core.* The core is made of paper coated with a colloidal mixture of Fe particles, alcohol and shellac and laminated with chlorinated naphthalene.

(4390) German 626,083 (1936). I. G. Farbenindustrie A. G., *Powdered Alloys for Electromagnetic Products.* Powdered alloys for electromagnetic purposes are produced by thermally decomposing metal carbonyls, mixing the product with a powder to prevent sintering, then heating the mixture in an inert atmosphere to obtain alloying in the individual particles by diffusion.

(4391) Brit. 463,030 (1937). Siemens & Halske A. G., *Magnetic Alloys for Cores.* Sintered cores consist of Fe, and Ni, as major constituents, and Cu as an additional element.

(4392) French 813,068 (1937). Siemens & Halske A. G., *Magnetic Alloys for Cores. Cf.:* Brit. 463,030 (No. 4391).

(4393) U. S. 2,068,658 (1937). I. W. Cox (Associated Electric Laboratories), *Loading Coil Core.* A core of oxide coated Fe particles is tumbled in Al vapor to convert the oxide to Al_2O_3 and then mixed with alundum.

(4394) U. S. 2,076,230 (1937). R. Gillis (Western Electric Co.), *Magnetic Dust Core.* A compressed magnetic powder is sprayed with an aqueous solution of $Pb(BO_2)_2$, dried and heated to fuse the coating.

(4395) U. S. 2,085,830 (1937). S. Ruben, *Pressed Dust Magnet.* Metallic magnetic particles are milled with powdered V_2O_5, which acts as a binder on pressing and heating.

(4396) U. S. 2,090,991 (1937). O. Wohlfarth and A. Agricola (Allgemeine Elektrizitäts Gesellschaft), *Radio Frequency Core.* A magnetic dust core is formed into an adjacent cooperating cup-shaped member to form an enclosure for the coil.

(4397) Brit. 486,778 (1938). General Electric Co. and C. G. Smith, *Finely Divided Magnetic Material.* Powdered magnetic metals, *e.g.* Fe-Ni, Fe-Si, or Si-Fe, and refractory powders are mixed and heated above the melting point of the Fe alloy, then the magnetic material is separated from the refractory material to produce spherical particles of predetermined size for use as high frequency inductances.

(4398) Brit. 487,143 (1938). Steatit-Magnesia A. G., *Magnetic Cores.* Magnetic cores are produced by molding a mixture comprising a finely divided ferromagnetic

material and a hardenable resin, heating at 250° C. (480° F.) so as to consolidate the shaped mass, and then subjecting the molded core to a treatment *in vacuo* to harden the resin.

(4399) Brit. 487,525 (1938). Siemens & Halske A. G., *Ferromagnetic Alloy for Powder Cores.* The alloy powder is produced by gaseous reduction of the oxides, with the gas brought into thermal equilibrum with the alloy at temperatures between 700° C. and 1300° C. (1290 and 2370° F.), and a separation of carbon resulting.

(4400) French 829,016 (1938). N. V. Philips' Gloeilampenfabrieken, *Magnetic Powder.* The powder consists of 7-9% Si, 6-11% Mn, remainder Fe.

(4401) French 835,401 (1938). I. G. Farbenindustrie A. G., *Metal Powder Cores.* Cores are produced from a mixture of a magnetic metal powder obtained from the decomposition of Fe carbonyl and a solution of sugar and resin.

(4402) German 667,919 (1938). C. Lorenz A. G., *Dust Core for High Frequency Coils.* Magnetic powder is coated with a synthetic resin and used for making dust cores.

(4403) U. S. 2,105,092 (1938). C. C. Neighbors (Western Electric Co.), *Magnetic Dust Core.* The Permalloy particles are insulated, compressed and then heat treated in N_2 for annealing.

(4404) U. S. 2,110,967 (1938). J. W. Andrews (Western Electric Co.), *Magnetic Materials and Method of Making such Materials.* A magnetic core of finely divided and insulated magnetic particles comprises a Ni-Fe alloy containing 5-20% Cu, 60-85% Ni, balance Fe.

(4405) U. S. 2,110,974 (1938). R. Gillis (Western Electric Co.), *Magnetic Dust Core.* The dust is heat treated in the presence of a carburizing agent and insulated; the pressed cores are heat treated with the carburizing agent.

(4406) U. S. 2,113,603 (1938). W. J. Polydoroff (Johnson Laboratories), *Magnetic Core.* A variable inductance device consists of a coil and a means for varying the effective inductance of the coil, comprising a compressed comminuted magnetic core, which is movable relative to the coil and has a varying magnetic density in the direction of the motion.

(4407) U. S. 2,117,856 (1938). B. Scheppmann (C. Lorenz A. G.), *High Frequency Core.* Fe powder is coated with amber, moistened with turpentine oil and compressed.

(4408) French 837,210 (1939). Lignes Télegraphiques et Télephoniques, *Insulating Magnetic Powder Particles in the Production of Pressed Cores.* A corrosive solution is used for insulating purposes.

(4409) German 670,898 (1939). International Standard Electric Corp., *Electromagnetic Cores.* Electromagnetic cores are produced by melting together 60-85% Ni, 5-20% Cu, remainder Fe and pulverizing the material.

(4410) German 673,830 (1939). Philips Patentverwaltung G.m.b.H. and J.L. Snoek, *Ferrous Alloy Suitable for Making Cores.* The powder composition consists of Fe, Mn, Si.

(4411) German 681,624 (1939). Siemens & Halske A. G., M. Kersten, and C. Kesselring, *Magnetic Cores.* A powdered ternary alloy of 40-80% Ni, 2-15% Cu and remainder Fe is used for magnetic cores.

(4412) U. S. 2,146,987 (1939). H. C. Riepka (Steatit-Magnesia A. G.), *High Frequency Core.* A cylindrical and threaded core, having opposite sides of the threaded body flattened to at least the depth of the thread, is pressed from Fe powder.

(4413) U. S. 2,154,730 (1939). I. W. Cox (Associated Electric Laboratories), *Magnetic Dust Core.* Powdered Fe, andalusite, Na-silicate and $(NH_4)_2CrO_4$ are heated to decompose the chromate and thereby oxidize any uncoated surface of the Fe.

(4414) U. S. 2,158,132 (1939). V. E. Legg (Bell Telephone Laboratories), *Temperature-Stabilized Nickel Magnetic Bodies.* A magnetic body comprises a mixture of finely divided Ni-Fe-Mo material and 0.25-1% stabilizing alloy containing 13% Mo, 80% Ni, and 7% Fe.

(4415) U. S. 2,162,273 (1939). W. Schulze (Allgemeine Elektrizitäts Gesellschaft), *Magnetic Dust Core.* Fe powder is first coated with amber varnish and then with polystyrol.

(4416) U. S. 2,169,732 (1939). V. E. Legg (Bell Telephone Laboratories), *Magnetic Bodies.* A powder for loading coil cores is suspended in a coating bath and agitated by compressional elastic high frequency waves.

(4417) U. S. 2,179,810 (1939). R. Brill and K. Schoenemann (I. G. Farbenindustrie A. G.), *Magnetic Substance.* A magnetic substance in finely divided form consists of a mixture of 94% Fe powder, 2% Al powder and 4% powdered CaO which is burnt in a stream of O_2.

(4418) German 690,916 (1940). Preh-Elektrofeinmechanische Werke, *Magnetic Powder for Dust Cores.* A finely divided magnetic powder is obtained by impregnating a porous mass of Al_2O_3 or MgO with an aqueous solution of a ferromagnetic salt, which after reducing, is separated.

(4419) German 692,975 (1940). C. Lorenz A. G., *Dust Core for High Frequency Coils.* Magnetic powder is coated with a synthetic resin and used for making dust cores.

(4420) German 700,751 (1940). Siemens & Halske A. G., *Iron Powder for High Frequency Cores.* The cores are produced by the decomposition of Fe carbonyls; the powder is worked mechanically without changes of form and size in a ball mill, before or during the insulation operation.

(4421) U. S. 2,186,659 (1940). H. Vogt (Micro Products Corp.), *Magnetic Powder for Iron Dust Cores.* The powder consists of Fe and 5-15% Si and is disintegrated mechanically and blown through a reducing flame to obtain a spherical particle shape.

(4422) U. S. 2,191,151 (1940). S. G. Hale (Bell Telephone Laboratories), *Magnetic Dust Core.* The core is temperature compensated by a mixture of Permalloy with fluorspar, having a larger coefficient of thermal expansion.

(4423) U. S. 2,199,526 (1940). J. L. McCowen (Imperial Chemical Industry Ltd.), *Material for Electromagnetic Cable-Sheaths.* Permalloy powder is mixed with an equal bulk of polymerized ethylene above 110° C. (230° F.).

(4424) U. S. 2,200,491 (1940). R. P. Cross and A. N. Ogden (Western Electric Co.), *Magnetic Alloy.* A powdered magnetic alloy is produced by melting, disintegrating, oxidizing, pulverizing and reducing a Ni-Fe alloy, *e.g.* containing 82% Ni, 16% Fe and 2% Mo.

(4425) U. S. 2,214,898 (1940). H. Brinkmann, *Magnetic Dust Core.* The core has a thermoplastic insulating jacket of a lower softening point than the binder of metal powder.

(4426) U. S. 2,218,669 (1940). A. D. Whipple (Johnson Laboratories), *Radio Tuning Core.* A compressed magnetic material has connecting eyelets molded in place at its ends.

(4427) Belgian 441,764 (1941). Fides, Gesellschaft für Verwaltung und Verwertung von Schutzrechten, and Siemens & Halske A. G., *Production of Magnetic Cores.* Fe powder is mixed with silicates, heated, dried and pressed to cores.

(4428) German 703,669 (1941). Philips Patentverwaltung G.m.b.H., E. W. Verwej, J. W. Evert and J. H. De Boer, *Magnetic Core.* Magnetic particles are coated with an insulating film of a metallic phosphate, applied from an ammoniacal solution of the salt by suspending the magnetic particles in it and subsequently heating the suspension to drive out the NH_3. A film of approximately 20 μ is thereby obtained.

(4429) German 707,479 (1941). Steatit Magnesia A. G., *Production of Cores from Insulated Magnetic Powder.* Magnetic cores are produced by pressing a pasty mixture of the magnetic powder with a solution of synthetic resin which is sprayed out through a nozzle so that the material is dried during settling.

(4430) German 712,675 (1941). I. G. Farbenindustrie A. G., *Insulation of Magnetizable Powders.* Fe-Ni powder for high frequency cores is mixed with kaolinite, Na-silicate and water, and then dried.

(4431) German 716,473 (1941). I. G. Farbenindustrie A. G., *Magnetic Dust Cores.* Carbonyl Fe is treated with 2% cane sugar solution to increase its insulating resistance before forming into cores.

(4432) Swedish 107,503 (1941). Licentia Patent-Verwaltungs-Gesellschaft m.b.H., *Method for Making Magnet Cores for High Frequency Applications and Cores Obtained by this Method.* In the manufacture of magnet cores from metal powders, *e.g.* Fe powders from Fe carbonyl, a process is used in which no heat treating is necessary.

(4433) U. S. 2,230,228 (1941). A. F. Bandur (Western Electric Co.), *Manufacture of Magnetic Cores.* The process comprises coating finely divided particles of a Ni-Fe magnetic alloy with mixture of $Mg(OH)_2$, Na-silicate and talc; an agent for separating particles is added. The mixture is heated, pulverized and pressed.

(4434) U. S. 2,231,160 (1941). P. Gottschalt (Siemens & Halske A. G.), *Inductance Core.* A core for coils used in oscillating circuits, having a low negative temperature coefficient of inductance, is squirted to the desired form from 50% Fe carbonyl powder and 50% polystyrol powder.

(4435) U. S. 2,232,352 (1941). E. W. Verwej and J. H. De Boer (Radio Corp. of America), *Magnetic Cores.* Powdered Fe is coated by a material which does not chemically transform the surface of the particles; the powder is mixed with weakly acid ferric phosphate of equal molecular amounts of ferric-ion and phosphate-ion, dried and re-powdered.

(4436) U. S. 2,238,893 (1941). E. Fischer (Siemens & Halske A. G.), *Magnetic Core.* A non-hygroscopic loading coil core has the magnetic particles bonded with polystyrene.

(4437) U. S. 2,241,441 (1941). A. F. Bandur (Western Electric Co.), *Magnetic Core.* The core is produced by subjecting insulated dust to a succession of compressing operations.

(4438) U. S. 2,255,873 (1941). A. F. Bandur (Western Electric Co.), *Treating Magnetic Material Such as That for Magnetic Dust Cores.* Magnetic properties of finely divided particles (*e.g.*, Ni-Fe-Mo alloy) are improved by heating within a walled container to eliminate deleterious gases, cooling in the container after removing the gas, with O_2 being removed from the air entering the container during cooling.

(4439) U. S. 2,261,425 (1941). C. Wentworth (Radio Corp. of America), *Method of Making Paramagnetic Materials.* A method of making paramagnetic particles of substantially curved contours involves dropping separate molten particles of a magnetic material into flaming alcohol.

(4440) U. S. 2,266,262 (1941). W. J. Polydoroff, *Antenna System for Wireless Communication.* Powdered Fe cores are used in a cylindrical aircraft direction finding loop-antenna.

(4441) Belgian 445,768 (1942). Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Compressed Cores Made of Alloys of Iron, Silicon and Aluminum.* The fused and cast alloys are combined at a temperature of 900-1100° C. (1650-2010° F.), ground, and annealed at 600-900° C. (1110-1650° F). The powder is then compressed into cores which are annealed at 600-800° C. (1110-1470° F.).

(4442) Belgian 448,447 (1942). B. M. S. Kalling, *Production of Magnetic Cores.* The cores are made from molten particles of Fe, decarburized at a temperature below the melting point, and then pressed.

(4443) German 716,472 (1942). O. Ludl and G. Kiessling (Allgemeine Elektrizitäts Gesellschaft), *Production of Insulated Magnetic Powders for Cores.* Particles of Fe carbonyl are first coated with an insulation, *e.g.* Al_2O_3, or Na-silicate, and then heated between 180 and 300° C. (355 and 570° F.) without pressing, to produce an insoluble coating.

(4444) German 717,111 (1942). Siemens & Halske A. G., M. Kornetzki, and F. Müller, *Powdered Metal or Alloy for Cores.* Powdered metal, *e.g.* Fe, oxides are reduced to a ferromagnetic state and treated while still in the furnace with oxidizing gases to prevent subsequent autoxidation and also to coat the particles with an insulating film.

(4445) U. S. 2,268,782 (1942). H. Stier, *High Frequency Core.* The core is composed of Fe powder and a semi-conducting binder containing C powder.

(4446) U. S. 2,277,474 (1942). F. Bergtold (Telefunken Gesellschaft für Drahtlose Telegraphie, m.b.H.), *High Frequency Coil Core.* A U-shaped core is compressed from interwoven stranded wires; the two ends consist of compressed magnetic powder.

(4447) U. S. 2,279,013 (1942). P. N. Roseby (Automatic Telephone & Electric Co.), *Nickel-Iron Powder Suitable for Dust Cores of Loading Coils.* Ni-Fe powder of predeterminated particle size is mixed with a definite proportion of an Fe compound capable of reduction, and having particles considerably smaller than the particles of Ni; the mixture is heated and sintered and then crushed to powder.

(4448) U. S. 2,292,838 (1942). P. H. Jones (Union Oil Co.), *Apparatus for Imparting Magnetic Properties.* An apparatus for imparting directional magnetic properties to core samples uses a highly ferro-magnetic powdered alloy as the magnetic material.

(4449) U. S. 2,306,198 (1942). E. W. Verwej (Radio Corp. of America), *Magnetic Cores.* The process comprises mixing powdered magnetic material with an H_2O-NH_3 solution.

(4450) Belgian 452,605 (1943). Siemens & Halske A. G., *Production of Magnetic Cores.* The cores are composed of metallic powders of great permeability and great hardness, *e.g.* an alloy of Fe-Al-Si with a thermoplastic binder.

(4451) Canadian 412,928 (1943). Micro-Products Corp. and H. Vogt, *Magnetic Powder.* Fe powder for cores of high frequency coils is produced by forming an alloy of Fe with 4-12% Al or Si, heating to promote aggregation of the C content, disintegrating to a size of less than 30 μ, and separating out the graphite.

(4452) German 731,409; 736,436 (1943). Fried. Krupp A. G., *High Frequency Cores.* The cores consist of 10-40% Cr, 10% Si or Al, remainder Fe.

(4453) German 737,312 (1943). Fried. Krupp A. G., *High Frequency Cores.* The cores are composed of 0.5-10% Cr, 4-10% Al, remainder Fe.

(4454) Swedish 107,500 (1943). B. M. S. Kalling, *Method for Making Magnet Cores.* Cores are made by mechanically reducing cast Fe to a fine-grained form and then decarburizing it at a temperature below the melting point.

(4455) U. S. 2,307,343 (1943). A. D. Whipple (Johnson Laboratories), *Ferromagnetic Powder Core.* The compressed core is treated by impregnation in a hot solution of water-insoluble metallic soap in a non-drying oil.

(4456) U. S. 2,330,590 (1943). K. Kaschke, *Ferromagnetic Core.* Fe powder is compressed to a high frequency magnetic core.

(4457) German 744,149 (1944). C. Lorenz A. G., *Magnetic Core.* Fe and Ni powders, produced from their carbonyls, are mixed with 3% phenol formaldehyde condensation products, and pressed and heated.

(4458) German 745,716 (1944). Metallgesellschaft A. G., *Trunk Line.* A trunk line has magnetic bodies surrounding the wire, which consist of pressings of magnetic powder which alternate with pressings of MgO.

(4459) German 748,122 (1944). W. Schulze, *Magnetic Core Produced from Powders.* The binder for the magnetic powder consists of a mixture of acrylonitrile and an ethylic ester of acrylic acid which is mixed with 60% of a hardenable condensation product of phenol formaldehyde.

(4460) U. S. 2,339,137 (1944). G. Berge, *Ferromagnetic Core.* The core is constructed of powdered Sn and Fe oxides.

(4461) U. S. 2,340,749 (1944). R. L. Harvey (Radio Corp. of America), *Tuning System.* A variable permeability tuning system is provided with tuning cores of a magnetic material, such as Fe powder.

(4462) U. S. 2,343,999 (1944). J. P. Putnam, (Reece Button Hole Machine Co.), *Inductor.* A variable inductor having stator core and shell members is molded from Fe powder and a binder.

(4463) U. S. 2,354,331 (1944). W. J. Polydoroff, *High Frequency Inductor.* The inductor has a magnetic core compressed of metal powders to a high density.

(4464) U. S. 2,354,332 (1944). W. J. Polydoroff, *Loop Antenna.* The antenna has an associated core composed of finely divided insulated magnetic particles.

(4465) U. S. 2,357,442 (1944). S. H. M. Dodington (Federal Telephone & Radio Corp.), *Radio Receiver.* A high frequency amplifier has a powdered Fe plunger of paramagnetic material.

(4466) U. S. 2,359,684 (1944). W. F. Sands (Radio Corp. of America), *Loop Input System for Radio Receivers.* Radio receivers have ferromagnetic cores produced from powders.

(4467) U. S. 2,360,939 (1944). J. F. Dillinger and A. N. Ogden (Western Electric Corp.), *Magnetic Materials.* A stabilizer material for magnetic cores contains particles having a variety of Curie points; the material consists of 80% Ni, 12-13% Mo, remainder Fe.

(4468) U. S. 2,361,634 (1944). W. R. Koch (Radio Corp. of America), *Record Reproducing Circuit.* A capacity pick-up device for phonograph records has a coil with a core of powdered Fe.

(4469) U. S. 2,361,748 (1944). G. P. Daiger and W. H. Kitto (Hoover Co.), *Dynamoelectric Machine.* The core for a dynamoelectric machine is molded from magnetic particles mixed with insulating binder.

(4470) U. S. 2,365,720 (1944). C. C. Neighbors (Johnson Laboratories), *High Frequency Core.* The compressed ferromagnetic core consists of minute particles of magnetic oxide of Fe in substantially spherical form.

(4471) Brit. 567,489 (1945). Telephone Mfg.Co.Ltd. and L.H. Paddle, *Ferromagnetic Powder.* Ferromagnetic powders, *e.g.* Fe-Ni, used in the manufacture of electrical inductance coils, are prepared by mixing an embrittling agent to the powder prior to compressing and heating for 1-4 hours, after which it is quenched and pulverized.

(4472) Brit. 571,676 (1945). Standard Telephones & Cables Ltd., *Magnetic Articles.* Articles having a high magnetic permeability are made by pressing to shape a comminuted mass of Fe-Co alloy, containing 30-70% Fe, and 70-30% Co.

(4473) U. S. 2,368,857 (1945). G. B. McClellan (Johnson Laboratories), *High Frequency Core.* An inductance unit has a core of powdered Fe.

(4474) U. S. 2,384,215 (1945). H. A. Toulmin (H-P-M Development Corp.), *Powder Metallurgy for Production of High-Frequency Cores.* Articles are produced from metal powders of which at least one portion is magnetic by subjecting the powder in a mold to a magnetic field and mechanical vibration and heating and pressing in the same mold to produce the finished article.

(4475) U. S. 2,385,578 (1945). K. Kaschke, *Iron Powder Core.* A compressed Fe dust core, whose length is a multiple of its diameter, is used for permeability tuning devices.

(4476) U. S. 2,388,295 (1945). R. F. Shea (General Motors Co.), *Transformer.* A single powdered Fe body is used in a radio frequency transformer.

(4477) U. S. 2,388,664 (1945). A. F. Bandur, J. F. Dillinger and A. N. Ogden (Western Electric Co.), *Magnetic Material.* A pressed magnetic core material having a substantially constant permeability consists of particles of an alloy containing chiefly Ni and Fe, coated with an insulating material containing Na-silicate, and a permeability stabilizing filler, such as powdered pyrex glass.

(4478) U. S. 2,389,879 (1945). H. Tunick (Radio Corp. of America), *Frequency Modulation.* A frequency modulator is provided with a powdered Fe core.

(4479) U. S. 2,391,229 (1945). F. R. D'Entremont (General Electric Co.), *Induction Apparatus.* Fe powder is used in a magnetic cement in forming an induction core.

(4480) U. S. 2,391,563 (1945). S. Goldberg (Super Electric Products Co.), *High Frequency Coil.* The coil is composed of magnetite and carbonyl Fe particles, insulated with a bakelite varnish.

(4481) Brit. 578,250 (1946). Standard Telephones & Cables Ltd., *Magnetic Alloy Powder.* A magnetic Fe-Ni-Mo alloy powder is heat treated in an inert atmosphere at 630° C. (1160° F.) to improve its permeability, and then coated with a resin binder.

(4482) French 911,183 (1946). Lignes Télegraphiques et Télephoniques, *Dust*

Cores for High-Frequency Coils. High-speed production of dust cores is obtained by using an extrusion press and cutting to size.

(4483) U. S. 2,393,295 (1946). R. P. Cross, Jr., J. F. Dillinger and A. N. Ogden (Western Electric Co.), *Magnetic Materials.* A method of preparing magnetic material comprises compacting a mixture composed of about 12% Mo, 80% Ni, rest Fe, heating the compacted mixture in a reducing atmosphere to sinter, powdering the sintered material, adding the powdered material to insulated Permalloy dust and compacting the product into cores.

(4484) U. S. 2,401,882 (1946). W. J. Polydoroff (Radio Corp. of America), *Ultra High Frequency Inductor.* The core of the high frequency transmitter coil is composed of metal particles formed into a number of sections with an air spacing between them and mounted upon an insulating rod.

(4485) U. S. 2,407,234 (1946). R. G. Guthrie and J. Chumasero (Minneapolis Honeywell Regulator Co.), *Magnetic Core.* A sintered magnetic core for use in relays is formed of an alloy of Ni, Mo and Fe.

(4486) U. S. 2,411,810 (1946). M. Sander (Radio Corp. of America), *Magnetic Core.* A core of powdered Fe is used in an audio reactor for varying the inductance.

(4487) U. S. 2,412,668 (1946). A. F. Bandur (Westinghouse Electric & Mfg. Co.), *Magnetic Core Body.* A magnetic core body consists of particles of magnetic materials insulated from one another and bonded together by the end products of a heat-treated composition comprising a water-soluble soap of glycerol-phthalate and casein.

(4488) U. S. 2,412,772 (1946). C. W. Hansell (Radio Corp. of America), *Magnetic Core.* A core produced from Fe dust is used in an electron discharge device oscillator.

(4489) U. S. 2,412,805 (1946). J. R. Ford (Radio Corp. of America), *Magnetic Core.* An Fe dust core is used in an ultra high frequency oscillation generator.

(4490) U. S. 2,413,098 (1946). H. J. Benner and A. M. Hadley (F. W. Sickles Co.), *Inductance Core.* The core is made of powdered Fe, PbO and glycerine.

(4491) U. S. 2,413,201 (1946). J. E. Tillman (General Electric Co.), *Radio Frequency Transformer.* A body of powdered Fe is incorporated into a radio frequency transformer.

(4492) U. S. 2,413,607 (1946). M. J. Di Toro (Hazeltine Research Inc.), *Time-Delay Network.* A magnetic core of powdered Fe and graphite is used in the time-delay network.

(4493) Brit. 587,045 (1947). Aladdin Radio Patents Ltd. and H. F. Garrett, *High-Frequency Conductors.* High-impedance conductors for radio equipment are made by compressing a spiral of conductive wire in a mold filled with -400 mesh carbonyl Fe powder.

(4494) Brit. 587,138 (1947). Standard Telephones & Cables Ltd., *Magnetic Cores from Magnetic Dust.* Molten Ni-Fe-Mo alloy is atomized with a jet of cold water. The powder is graded to -14 + 120 mesh size-fraction, ball-milled, annealed at 900° C. (1650° F.) and repulverized.

(4495) Brit. 595,510 (1947). Standard Telephones & Cables Ltd., *Finely Divided Magnetic Material.* Permalloy ingots with a fine-grained structure are obtained by casting to a thickness of 3/4 inch, then pulverizing to a powder grade suitable for pressing to high frequency cores.

(4496) Brit. Appl. 7578/47 (1947). Philips Lamps Ltd., *Magnetic Material.* The magnetic properties of sintered Mn-ferrite are preserved by cooling the body from the sintering temperature in an atmosphere of gradually reduced partial O_2 pressure in superheated steam, or in a N_2-O_2 mixture with increasing N_2/O_2 ratio.

(4497) French 929,362 (1947). I. G. Farbenindustrie A. G., *Iron Powder for Magnetic Dust Cores.* Electrolytic Fe powder is heat treated in H_2 at 450° C. (840° F.) for 12 hrs. or at 600° C. (1110° F.) for 24 hrs.; the product is then ball-milled.

(4498) U. S. 2,418,467 (1947). W. C. Ellis and A. G. Souden (Bell Telephone Laboratories), *Magnetic Materials for Dust Cores.* Magnetic properties of finely

divided Fe_3O_4 are substantially improved by heating at 1000° C. (1830° F.) in an inert atmosphere for ½ hour.

(4499) U. S. 2,419,847 (1947). A. F. Mittermaier (General Electric Co.), *Powdered Iron Magnetic Cores.* A mechanically strong uncompressed magnetic core material and powdered insulating material, *e.g.*, clay, comprises particles of powdered Fe bonded together by a polymerized alcohol ester of carboxylic acid.

(4500) U. S. 2,423,275 (1947). C. W. Wandrey (Zenith Radio Corp.), *Mechanism for Radio Receivers.* Flexible means is used for driving the core of powdered Fe, whereby axial forces applied to the core through the resilient element do not change its length.

(4501) U. S. 2,427,872 (1947). W. E. Newman (Radio Corp. of America), *Tapered Magnetic Core.* A cylindric magnetic core of powdered Fe with longitudinal grooves of gradually varied depth has magnetic material in the form of pellets, deposited in the grooves on the leading end of the core in an adhesive carrier.

(4502) U. S. 2,431,425 (1947). W. F. Sands (Radio Corp. of America), *Variable Inductance Device.* The device has a cylindrical core of two semi-circular extending portions; one consists of Fe powder and the other of a high conductivity nonferrous material.

(4503) U. S. 2,432,715 (1947). H. J. Benner and A. M. Hadley (F. W. Sickles Co.), *Inductance Coil Structure.* The core of the tube is produced of powdered Fe and PbO mixed with glycerine to a paste which is hardenable without heat and pressure.

(4504) U. S. 2,433,004 (1947). J. E. Tillman (General Electric Co.), *Radio Frequency Transformer.* The transformer has a movable closed magnetic body of a pair of circular cup-shaped members, formed from Fe powder, in which is a fixed core of Fe powder.

(4505) Brit. 603,309 (1948). "Patelhold" Patentverwertungs- & Elektro-Holding A. G., *Bodies of Powdered Magnetic Material.* The core and the shell of the magnet are made of materials with different permeabilities, *e.g.* carbonyl Fe-resin mixes of 30:1 and 10:1 respectively.

(4506) Brit. 604,169; 604,170 (1948). Standard Telephones & Cable Ltd. and W. E. Laycock, *Magnetic Dust Cores.* The cores are made by coating -400 mesh Mo-Permalloy powder successively with silica sol, $Mg(OH)_2$ and TiO_2; the particles are compacted and annealed in inert gas.

(4507) Brit. Appl. 7000/48 (1948). Communication Engineering Proprietary Ltd., *Coating of Magnetic Powder.* Carbonyl Fe is mixed with 3-10% of Na-perborate into a slurry, water is driven off, and the perborate is reduced to metaborate, the O_2 evolved tending to break up aggregates of Fe powder. After pressing, the cores are heated at 120-180° C. (230-356° F.), cooled and coated with lacquer.

(4508) Dutch 61,937 (1948). N. V. Philips' Gloeilampenfabrieken, *Magnetic Ferrous Material.* A material suitable for cores consists of cubic mixed crystals of a mixed compound of Zn-ferrite and a ferromagnetic ferrite. By sintering and cooling the material in an O_2 atmosphere, the O-content of the material is so adjusted that the initial permeability is 60.

(4509) French 934,598 (1948). Office National Industriel de L'Azote, *Manufacture of Iron Powder for Dust Cores.* Electrolytic Fe powder is ball-milled, heated first in N_2 and then in H_2, and again ball-milled, before pressing into core shapes.

(4510) French 937,076 (1948). N. V. Philips' Gloeilampenfabrieken, *Magnetic Core Composed of Ferromagnetic Ferrite.* Ferrites are mixed with positive and negative magnetostriction in a predetermined ratio. The properties of Mn-Zn-ferrites and Ni-Zn-ferrites are described.

(4511) French 940,568 (1948). J. Gourevitch and A. P. Metroz, *Magnetic Dust Core.* Several arrangements for permeability tuning are given in which a magnetic ring is displaced axially in relation to the cored coil.

(4512) French 944,911 (1948). M. De Marotte De Montigny, *Magnetic Cores for Coils in Oscillating Circuit.* Various split cores are designed so that contact is effected in a direction parallel with that in which the parts are put together, thus eliminating the influence of glue material.

(4513) U. S. 2,438,680 (1948). W. J. Polydoroff, *Loop Antenna.* The antenna has an elongated tubular ferromagnetic core, made in sections of finely divided and compressed magnetic particles, and coils over the length of the core, serially connected to increase the permeability of the core.

(4514) U. S. 2,438,770 (1948). J. E. Tillman (General Electric Co.), *Transformer for Radio Receiver.* The magnetic body of the transformer is formed as a unit structure of compressed Fe particles, and has a pair of recesses, in which cores of powdered Fe are movable, for adjusting the inductance of the coils.

(4515) U. S. 2,452,529; 2,452,530; 2,452,531 (1948). J. L. Snoek (Hartford National Bank & Trust Co.), *Low-Loss and High-Resistance Magnetic Core.* Pure oxides of metals, such as Cu, Zn, Cd, Ni, or Mg, and Fe_2O_3, are sintered together to form ferrites and ground in a ball-mill; the powder then is molded onto a ring and heated. The permeability is improved by repeated sintering and grinding.

(4516) Brit. 614,181 (1949). Philips Lamps Ltd., *Manufacturing Magnetic Cores.* 250 g. of a 2:3:5 mixture of CuO, ZnO and Fe_2O_3 are mixed with 45 g. of a solution of 18% nitrocellulose in a solvent of 50 parts butyl acetate, 25 parts butanol and 15 parts ethyl glycol; the extruded tube is sintered.

(4517) Brit. 614,476 (1949). Standard Telephones and Cables Ltd. and W. E. Laycock, *Magnetic Bodies from Finely Divided Material.* The powder is insulated with a thermosetting resin, cooled, comminuted and compacted. The cooling is effected in a refrigerator or by admixing liquid air or CO_2.

(4518) Brit. 619,779 (1949). General Aniline & Film Corp., *Iron Powder and Cores Produced Therefrom.* Carbonyl Fe powder of less than 12 μ is reduced to a content of 0.012%; the powder is then mixed with 20% butyl alcohol. After heat treatment and grinding, the coated powder is pressed to a density of 7.35, and then heated at 150° C. (300° F.).

(4519) Brit. 620,009 (1949). Philips Lamps Ltd., *Magnetic Core.* The cores are made from sintered ferrites and impregnated with vaseline.

(4520) Brit. 620,269 (1949). The General Electric Co. Ltd. and P. R. Bardell, *Magnetic Dust Cores.* The cores are made by mixing 80-20 Fe-Ni powder with an aqueous paste of 3.5-10% china clay and 1.5-3% water glass; the mixture is heated, milled, and reheated to 600° C. (1110° F.) in a reducing atmosphere.

(4521) Brit. 621,013 (1949). The General Electric Co. Ltd. and A. D. Thomas, *Magnetic Dust Core.* 50-50 Ni-Fe is mixed with a solution of Na-silicate and heated to drive off moisture; polyethylene dissolved in trichlorethylene is added to the powder and the mixture is then extruded.

(4522) Brit. 621,447 (1949). The Plessey Co. Ltd., *Slide Wire Permeability Tuning Unit.* A compact inductance tuning arrangement with a linear frequency response is obtained by using a dust core with a tapered inner surface.

(4523) Brit. 624,750 (1949). P. L. M. Hatte, *High Frequency Cores.* Nylon-bonded dust cores are made by mixing the magnetic powder with a gel of colloidal Nylon, then rolling it into corrugated strip, drying and crushing; the fragments are pressed into cores.

(4524) Brit. 624,767 (1949). Communication Engineering Proprietary Ltd., *Closed Core-Type Coil.* The cores of two cored coils are joined by end pieces, the joints being effected by means of a carbonyl Fe suspension in an alcohol solution of phenol-formaldehyde resin.

(4525) Brit. 625,485 (1949). The British Thomson-Houston Co. Ltd., *Magnetic Recording and Reproducing of Sound.* Recording disks are made from Si-steel coated with a mixture of 43.6% Fe_3O_4, 30.1% Fe_2O_3 and 26.3% Co_2O_3 in thermoplastic resin. The mixed oxides are briquetted, sintered and reground to a size smaller than 0.001 in.

(4526) Brit. 625,627 (1949). The Plessey Co. Ltd., G. C. Gaut and N. C. Moore, *Magnetizable Divided Bodies.* Laminated cores for transformers or chokes are made from flaked electrolytic Fe powder. The powder is rolled twice or three times with intermediate annealing, then mixed with SiO_2; the mixture is then annealed in H_2. The flakes are separated magnetically, lightly oxidized, and impregnated with wax.

(4527) Brit. 628,812 (1949). Philips Lamps Ltd., *Moving-Core Inductance Coils.* The varying coupling that is set up between the coil and metal base by adjustment

of the core is eliminated by interposing a short-circuited Cu coil.

(4528) Brit. 628,823 (1949). Philips Lamps Ltd., *Inductances.* Coil losses are reduced by using Ferroxcube material as the shell, either with a powdered Fe core or a Ferroxcube core.

(4529) Brit. 629,031 (1949). Philips Lamps Ltd., *Ferrites and Ferrite Cores. Cf.:* French 937,076 (No. 4510).

(4530) Brit. Appl. 8056/49 (1949). Philips Electrical Ltd., *Magnet Cores.* Mn-ferrite with specified ranges of atom ratios are suitable for magnetic cores for high-frequency inductance coils or transformers.

(4531) Brit. Appl. 14875/49 (1949). Soc. D'Électro-Chimie, D'Électro-Métallurgie et Des Aciéries Électriques D'Ugine, *Manufacture of Ferrites for Magnetic Cores.* Mixed ferrite powders are obtained by precipitating with NH_4 oxalate from a hot mixed salt solution and decomposing in air.

(4532) Brit. Appl. 15008/49 (1949). Aladdin Industries Inc., *Magnetic Core Composition.* The inclusion of 2-12% $PbTiO_3$ in mixed ferrite cores gives improved Q values and tuning ranges and reduces markedly the thermal drift of the core.

(4533) U. S. 2,458,282 (1949). G. J. Maki (Collins Radio Co.), *High-Power Permeability Core Inductance.* The construction makes it possible to use powdered Fe core inductances in radio transmitters, induction heating equipment and other apparatus which is required to operate at high power levels.

(4534) U. S. 2,461,397 (1949). K. B. Ross, *Permeability-Tuned Transformer.* Powdered Fe cores are used in this transformer.

(4535) U. S. 2,462,423 (1949). W. J. Polydoroff, *Ferromagnetic Variable High-Frequency Inductor.* The inductor, useful for remote control tuning of a high frequency circuit, uses a core composed of two elongated sintered cylinders. The permissible core permeability may be controlled by using a coarser grain of powdered material or by further sintering.

(4536) U. S. 2,462,435 (1949). R. E. Stanton, *Apparatus for Uninterrupted Reproduction of Disk Phonograph Records.* In the device, both the recorder magnet and the takeoff magnet have laminated cores so as to reduce the hysteresis and the resultant magnetic lag and heat to a minimum. Cores and other parts are made from compressed, powdered Fe or other suitable material.

(4537) U. S. 2,462,884 (1949). H. P. Miller, Jr. (Federal Telephone & Radio Corp.), *Electrical Choke.* The choke includes a coil wound around a linear axis. The core assembly includes a number of core sections, each consisting of several Fe dust cylinders aligned in an annular array.

(4538) U. S. 2,465,284 (1949). P. L. Schmidt (Westinghouse Electric Corp.), *Magnetic Sheet Coatings.* Insulated magnetic sheet material is coated with an insulating film made up of thermosetting melamine-formaldehyde resin and less than 35% finely divided solids distributed in the resin. Powdered Fe and Ni may be coated with the resin to produce resin-bonded magnetic cores suitable for various applications.

(4539) U. S. 2,475,321 (1949). C. A. Horn (H. L. Crowley), *Molded Core.* An Fe powder core has a molded-in threaded rod projecting beyond one face of the core. The rod to be inserted is mounted in a central bore of one of the movable punches.

(4540) U. S. 2,483,900 (1949). J. J. C. Hardenberg and W. Six (Hartford National Bank & Trust Co.), *Coil Having a Ferrite Core.* The adjustment of the air gap is described in the manufacture of Ferroxcube pots.

5. FERROUS MATERIALS AND PRODUCTS

A. Iron and Carbon Steels

(4541) U. S. 815,419 (1906). H. C. Gesner, *Articles of Alloys of Iron and Hydrogen.* The production of an alloy of Fe and H consists of moistening the powdered alloy and compressing and heating to frit or partially fuse, and thus agglomerate the powder into a strong, coherent body.

(4542) German 306,772 (1918). Allgemeine Elektrizitäts Gesellschaft, *Iron Powder Articles.* A method of producing articles from pure electrolytic Fe powder comprises forming the material into shape through high pressure and in inert atmosphere without sintering.

(4543) U. S. 1,453,057 (1923). J. A. Williams, *Process of Making Iron and Steel Alloys.* The process consists of oxidizing Fe or steel scrap, reducing the oxide to powdered metallic form and subsequently treating to produce a solid metallic body.

(4544) Brit. 213,214 (1924). General Electric Co. Ltd., *Manufacture of Hard Alloys for Tools.* As starting material an Fe substance of high C content is employed, which is heated in an electric arc in C-free atmosphere, until the correct C content remains; then the temperature is dropped rapidly to red heat, to produce a very fine homogeneous microcrystalline structure.

(4545) German 493,778 (1930). I. G. Farbenindustrie A. G., *Production of Pure Iron.* Fe, produced by decomposition of Fe carbonyls which contain C and O_2, is sintered or melted while protected from the air.

(4546) German 513,362 (1930). I. G. Farbenindustrie A. G., *Production of Pure Iron.* Addition to German 493,778 (No. 4545). Fe with an excess of C, produced from carbonyls, is mixed with Fe with an excess of O, in such a proportion that the excess of both is removed during sintering or melting.

(4547) U. S. 1,775,358 (1930). W. H. Smith (General Reduction Co.), *Uniting Iron with Other Metals and Elements.* Fe alloy articles are produced by mixing finely divided Fe with C, and subjecting the mixture to heat and pressure. The finished article has a varying C content and density.

(4548) German 541,515 (1931). I. G. Farbenindustrie A. G., L. Schlecht and W. Schubardt, *Production of Porous or Non-Porous Pressed Metal Bodies by Pressure and Sintering.* Porous or dense bodies are produced from carbonyl Fe-group powder mixtures.

(4549) U. S. 1,878,539 (1932). G. A. Reinhardt and R. H. Eurich, *Manufacture of Ferrous Articles.* Fe articles are made by pressing cold molded sponge Fe to a form approximating that of the desired shape, but with dimensions somewhat greater in all directions; the molded article is then heated to its thermal-critical range and allowed to cool to reduce the dimensions to the desired size.

(4550) German 583,989 (1933). I. G. Farbenindustrie A. G., *Production of Sintered Bodies.* The bodies are produced from sheet Fe scrap mixed with Fe powder, which is sintered in H_2 atmosphere; the resulting block can then be rolled out.

(4551) U. S. 2,100,537 (1937). M. J. Conway, *Ferrous Metal.* Fe metal articles are made from particles of solid steel, Fe, or steel and Fe material, to whose surface is applied a coating of a corrosion resistant; the oxide-coated particles are then hot pressed to a coherent mass.

(4552) U. S. 2,213,523 (1940). W. D. Jones and E. J. Groom, *Manufacture of Carbon Steel Articles.* A sintered agglomerated powder of white cast Fe is bonded by an Fe-C-P eutectic to yield C-steel.

(4553) Brit. 538,227 (1941). W. A. Oubridge, *Metal Articles.* Metal articles and masses having characteristics of gray Fe are made from soft Fe powder with a smaller proportion of hard Fe powder and 1-3% powdered graphite with a binder of ferrophosphorus powder; the mixture is pressed and sintered.

(4554) U. S. 2,238,382 (1941). A. L. Boegehold (General Motors Corp.), *Formation of Ferrous Metal Powders and Formation of Articles by Sintering.* The process comprises mixing low C content Fe particles with high C content (1.7%) Fe particles, pressing in a form, and heating to a temperature less than the melting point of low Fe and at least as high as the melting point of the Fe-Fe_3C eutectic.

(4555) Belgian 447,274 (1942). Deutsche Gold- und Silberscheideanstalt and J. A. Henckels, *Fabrication of Cutting Edges.* Steel powder, mixed with a binder, is pressed into the desired shape, and then sintered.

(4556) U. S. 2,275,420 (1942). F. H. Clark and R. F. Dirkes, *Metallurgy of Ferrous Metals.* Composite articles of hardenable steel suitable for making dies are formed by compressing Fe powder combined with C and sintering.

(4557) U. S. 2,284,638 (1942). F. H. Clark and R. F. Dirkes, *Metallurgy of Ferrous Metals.* Hardenable C steel is produced by mixing powdered Fe and powdered Fe_3C, pressing, heating in a non-oxidizing atmosphere, and sintering to cause diffusion.

(4558) U. S. 2,289,897 (1942). C. C. Balke and K. Misegades (Fansteel Metallurgical Corp.), *Ferrous Powder Metallurgy.* Fe bodies are produced by purifying Fe-C particles containing undesired impurities, depositing on their surface an amount of ductile constituents of steel free of C to produce a powdered material of the desired final analysis, pressing, and maintaining the pressed bodies at elevated temperature for a length of time sufficient to produce in the bodies the desired dense metallurgical structure.

(4559) U. S. 2,295,334 (1942). F. H. Clark and R. F. Dirkes, *Metallurgy of Ferrous Metals.* Hardened steel parts are made from pressed metal powders, *e.g.* carburized sponge Fe.

(4560) U. S. 2,300,118 (1942). F. R. Hensel, E. I. Larsen and O. L. Fluharty (P. R. Mallory & Co. Inc.), *Lapping Carrier.* The body is produced from Fe powder, pressed to a density of 4.5-5 g./cc. and sintered in H_2 at 1000° C. (1830° F.); the compact is strong, though of 35-40% porosity.

(4561) U. S. 2,301,805 (1942). O. Harder (Globe Steel Abrasive Co.), *High-Carbon Ferrous Base Composition for Producing Articles by Powder Metallurgy.* Bearings and parts are manufactured from powders of a high-carbon-chilled white cast Fe composition and heat treated. The particles consist of 2.0-3.8% C, 0.50-2.60% Si, 0.2-1.0% Mn, 1.0% P, up to 0.3% S, balance Fe.

(4562) U. S. 2,315,302 (1943). R. U. Volterra (American Electro Metal Corp.), *Process of Manufacturing Shaped Bodies from Iron Powders.* Dense steel bodies are obtained from a mixture of different kinds of Fe powder.

(4563) Brit. 558,810 (1944). I. Rennerfelt, *Shaped Objects from Carbon-Containing Iron.* Objects are formed from C-containing Fe in finely comminuted form by decarburizing the grains in a hot gas mixture.

(4564) Brit. 560,986 (1944). I. Rennerfelt, *Formed Objects from Finely Divided Pig Iron.* Objects are made by shaping in the cold or hot state granulated material produced by rapidly cooling liquid pig iron in a cooling medium and subjecting the grains to a dry oxidizing or decarburizing process.

(4565) U. S. 2,342,799 (1944). C. G. Goetzel (American Electro Metal Corp.), *Process of Manufacturing Shaped Bodies from Iron Powders.* Sintered C steels are manufactured by cementing hard, non-compressible steel particles with a soft, ferritic binder, preferably of low-density sponge Fe; the cementing phase is added by various methods and homogeneous steel structures are obtained by diffusion sintering at temperatures above 1150° C. (2100° F.).

(4566) U. S. 2,349,266 (1944). J. C. Hartley (Minerals & Metals Corp.), *Iron or Steel Product.* An Fe or steel product containing P, S, or Si is produced by directly reducing the finely divided Fe ore with its aforementioned constituents and compacting the reduced powder and then forming it into the desired product.

(4567) U. S. 2,352,316 (1944). C. G. Goetzel (American Electro Metal Corp.), *Method of Producing Shaped Bodies from Powdered Ferrous Material.* Steel bodies are made by cementing hard crushed steel with a soft ferritic binder. Sintering is carried out at closely controlled high temperatures between 1150 and 1300° C. (2100 and 2370° F.). Compacts are protected from decarburization by encasing them

in refractory coats impervious to gases and removable by washing in water after sintering.

(4568) Brit. 573,077 (1945). J. W. Lennox, *Manufacture of Articles from Metal Powder.* Fe powder containing less than 1% C is pressed cold and sintered in a carburizing atmosphere; *e.g.*, Swedish Fe powder containing 0.2% C is mixed with 3% of powdered Fe-Fe phosphide eutectic, and 1.75% graphite, sintered in an atmosphere of 100 parts H_2 and 20 parts coal gas, and then pressed in form of a piston ring.

(4569) U. S. 2,369,211 (1945). F. H. Clark and R. F. Dirkes, *Tool Steel.* Steel of extreme hardness and resistance to wear is made by producing a mixture of powdered Fe containing a metallic carbide, pressing and heating to cause the Fe to combine with the desired quantity of C.

(4570) Brit. 574,479 (1946). Minerals & Metals Corp. and A. H. Stevens, *Iron and Steel Products.* The products are made directly from the ores containing S, P, Ti, Si by direct reduction of the powdered concentrates at a temperature below the melting or sintering temperature; the resulting metal powder is compressed and sintered to the final product.

(4571) Brit. Appl. 34522/46 (1946). D. Primavesi, *Sintered Bodies from Metal Powders.* Fe or steel compacts are sintered in an atmosphere of partially burnt producer gas, from which sufficient CO_2 is removed to give a neutral atmosphere.

(4572) Brit. Appl. 34525/46 (1946). D. Primavesi, *Sintered Steel.* Partially burnt producer gas is used for the carburizing of Fe powder pressings, which are compacted at 25 tsi; the products are then repressed and sintered.

(4573) U. S. 2,411,073 (1946). L. F. Whitney (Isthmian Metals Inc.), *Making Products of Iron or Iron Alloys.* A method of making a body from Fe powder comprises first shaping the body by compressing at about 40 tsi, to form a compact, sintering, pressing at about 60 tsi and sintering again.

(4574) Belgian 473,774 (1947). P. Werner (Metallwerk Plansee G.m.b.H.), *Gear with Interchangeable Teeth. Cf.:* Austrian 162,779 (No. 4579).

(4575) Brit. Appl. 34524/47 (1947). D. Primavesi, *Production of Compact Sintered Bodies by Pressing and Sintering.* Cast Fe or Fe_2O_3 is added to the metal Fe powders as a pressing lubricant; alternatively, oxidized Fe powder is used.

(4576) French 928,574 (1947). Stahlwerke Roechling-Buderus A. G., *Products from Sintered Metals.* Fe parts requiring high strength values made from pure Fe powder are heat treated at 900-1200° C. (1650-2190° F.) with Fe sulfide in H_2S atmosphere, to produce a lower melting point eutectic; the compacts are also sintered in H_2S.

(4577) Italian 428,614 (1947). P. Werner (Metallwerk Plansee G.m.b.H.), *Gear with Interchangeable Teeth. Cf.:* Austrian 162,779 (No. 4579).

(4578) U. S. 2,435,511 (1948). R. E. Rice (Isthmian Metals Inc.), *Method of Making Metal Bodies.* Steel articles are made by subjecting a porous powder compact of Fe and C to a temperature above its critical temperature for a sufficient length of time to convert the mixture to the austenitic state, then quenching the compact below 550° C. (1000° F.) and subjecting the compact to an action of an accurately dimensioned die, while the Fe is in a predominantly austenitic state.

(4579) Austrian 162,779 (1949). P. Werner (Metallwerk Plansee G.m.b.H.), *Gear with Interchangeable Teeth.* The teeth consist of sintered Fe or steel, and are attached in different ways.

(4580) Austrian 163,161 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Steel Bodies.* Sintered steel bodies with 0.2-2% C are presintered at 700-1000° C. (1290-1830° F.), cold pressed and sintered at 1150-1300° C. (2100-2370° F.).

(4581) Austrian 163,162 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Steel Bodies.* The presintered bodies are pressed at 200-450° C. (390-840° F.) and then finished by sintering.

(4582) Austrian 163,404 (1949). Metallwerk Plansee G.m.b.H., R. Kieffer and S. Heiss, *Material for Heating and Cooking Devices.* The material consists of sintered Fe or sintered steel with 0.1-1.5% C.

(4583) Swiss 260,817 (1949). Metallwerk Plansee G.m.b.H., R. Kieffer, and S. Heiss, *Material for Heating and Cooking Devices. Cf.:* Austrian 163,404 (No. 4582).

(4584) Swiss 262,054 (1949). Metallwerk Plansee G.m.b.H., *Gear with Interchangeable Teeth. Cf.:* Austrian 162,779 (No. 4579).

(4585) Swiss 262,860 (1949). Metallwerk Plansee G.m.b.H., *Production of Sintered Steel Bodies. Cf.:* Austrian 163,161 (No. 4580).

(4586) U. S. 2,457,861 (1949). H. A. Brassert (H. A. Brassert & Co.), *Method of Manufacturing Metal Products.* Fe and steel products are produced directly from finely divided Fe oxides as a continuous process, involving the steps of reduction to an Fe sponge, densification by hot-pressing or hot rolling, and final annealing or sintering of the fully dense material.

(4587) U. S. 2,489,838 (1949). G. W. Webb (Isthmian Metals Inc.), *Powder Metallurgy Process for Producing Steel Parts.* A soft Fe compact free of oxide inclusions is made by loosely mixing powdered Fe with free C. The mixture is pressed at less than 40 tsi to form a coherent compact; this is sintered in a non-oxidizing atmosphere at the temperature at which the C and the sorbed O will combine to remove all the O from the compact and leave an excess of C in an amount not exceeding 0.4%.

(4588) U. S. 2,489,839 (1949). L. F. Whitney (Isthmian Metals, Inc.), *Process for Carburizing Compacted Iron Articles.* Pure Fe powder, which may contain desired amounts of powdered metallic alloying ingredients, is pressed in two or more pressing operations (40 tsi and then 60 tsi) with intervening sinterings at temperatures preferably above 870° C. (1600° F.). Densities of about 7.70 g./cc. or higher are thus obtained without the use of excessive pressures or temperatures. C is then introduced into the piece in the desired amount by a heat-treatment in a rapidly carburizing atmosphere.

B. Alloy and Stainless Steels

(4589) U. S. 1,506,246 (1924). G. F. McMahon, *Steel Alloy Material.* The production process comprises mixing pulverized electrolytic metal, *e.g.*, Fe containing H, with a metallic oxide containing material, *e.g.* NiO, sufficient to react with the H, and heating with the exclusion of extraneous gas to a temperature below the melting point of the Fe, thereby producing a sintered cake.

(4590) Brit. 317,998 (1929). I. G. Farbenindustrie A. G., *Alloys of Iron and Steel.* Powdered Fe or Fe oxides and other powders, such as Cr, W, Mn, Si, are reduced in H_2, pressed and sintered into steels.

(4591) Brit. 349,587 (1931). I. G. Farbenindustrie A. G., *Production of Alloys from Metal Powder.* Fe powder, produced from Fe carbonyl, is made into a paste with 20% $Cr(NO_3)_2$ solution and slowly heated until evolution of water vapor and oxides of N_2 has ceased; then the mass is treated at 1000° C. (1830° F.) with dry H_2 and the porous sintered slug is rolled into Cr-steel sheets.

(4592) French 704,503 (1931). R. Tschofen, *Hard Alloy.* The alloy contains 10% Al, 20% Cu, 20% Ni, 20% ferromanganese and 30% Fe.

(4593) German 532,409 (1931). I. G. Farbenindustrie A. G., *Production of Iron Alloys.* Fe produced from Fe carbonyls is mixed with Cr oxide powder and heated in H_2; the porous sintered alloy steel body is worked by hammering or rolling.

(4594) U. S. 1,815,613 (1931). G. J. Comstock (Firth Sterling Steel Co.), *Hard Metal Alloy.* An alloy steel is produced by combining WC, 3-20% Mn, and Mn steel containing 0.25-1.25% C, with a binder. The WC particles are embedded in the alloy steel which is hardened by slow cooling. The alloy steel is ultimately composed of 15% Mn and 1% C, or 3-20% Mn and 0.65-1.25% C.

(4595) U. S. 1,922,038 (1933). C. Hardy (Hardy Metallurgical Co.), *Iron, Nickel and Chromium Alloy.* A process for making a stainless metal composition comprises mixing finely divided (-200 mesh) particles with clean surfaces in the

following proportion: 74% Fe, 8% Ni, and 18% Cr. The mixture is pressed at 10 tsi and heated to above 900° C. (1650° F.) in a non-oxidizing atmosphere to form a homogeneous product.

(4596) Brit. 406,455 (1934). H. Esser, *Industrial Iron and Steel from Sponge Iron.* Fe sponge powder is mixed with powdered Cr, ferrochrome, Cr alloys, ferrophosphorus, Cu, Ni, Nichrome, Mo, and then pressed and sintered to give an alloy steel.

(4597) French 761,790 (1934). Soc. Industrielle & Commerciale Des Aciers, *Alloys.* Alloys which are hardened by segregation contain 10-30% W, 2-12% Mo (separately or together), 3-50% Co (preferably 25-50%), .1-.55% C, Fe, and at least 10% of an element (V, Ti, Ta) which has a greater affinity than W or Mo for C.

(4598) French 762,044 (1934). Soc. Industrielle & Commerciale Des Aciers, *Alloy Hardening by Segregation.* Alloys contain, besides Fe, 10-30% W, 2-12% Mo (separately or together), 25-30% Co and up to 10% of at least one other element (Ti, V, Ta, Cu, B, Al, Be) which produces hardening by segregation.

(4599) French 773,773 (1934). Soc. Industrielle & Commerciale Des Aciers, *Iron Alloys.* The alloys consist of 10-35% W, 0.1-0.4% C and up to 10% Ti, V, Ta, rest Fe, and are cooled rapidly from a temperature of 950° C. (1740° F.).

(4600) U. S. 1,977,361 (1934). C. Taylor, J. A. Weiger and G. N. Sieger, *Production of Sintered Rods.* A mixture of Ni, ferrochrome, ferromolybdenum, ferrotungsten, C and Fe is pressed and heated to between 1150-1250° C. (2100-2280° F.).

(4601) Brit. 424,282 (1935). Hardy Metallurgical Co., *Iron and Steel Alloys.* Stainless alloys from sintered Fe and Cr powders are produced by mixing finely divided Fe and Cr powder having clean metallic surfaces, molding the mixture under pressure and subjecting the briquette to a non-oxidizing treatment below the melting point, but at a high enough temperature so that the particles are bonded into a homogeneous product.

(4602) German 622,484 (1935). F. F. Gordon, *Compounded Metal Articles.* The bodies are produced by hot pressing from alloys containing Fe, Co, Ni, or Cr and at least 10% Mn to bind the Fe to steel.

(4603) Brit. 452,499 (1936). Vereinigte Edelstahl A. G., *An Improved Process for Making Sintered Metal Alloys.* A dense steel alloy or Fe-Mo-Ni alloy is produced by pressing and sintering *in vacuo* and H_2 alternately; the alloy is forged, rolled and mechanically worked.

(4604) German 633,300 (1936). Fried. Krupp A. G., *Alloy for Cutting and Hot Working Tools.* The alloy contains 10-30% W and/or 2-12% Mo, 0.1-0.55% C, 25-50% Co, and 10% V, Ti or Ta, remainder Fe.

(4605) Brit. 462,285 (1937). W. W. Triggs, *Hard Alloy.* A preformed body of tough Fe or steel contains on one side a non-workable alloy of 2-4% C, 0.2-25% B, 2½% Si, <0.1% S, <0.3% P, remainder Fe, which has a Brinell hardness above 500.

(4606) German 648,636 (1937). Fried. Krupp A. G. and H. H. Meyer, *Alloys.* Mixtures of metal carbonyls and metal salts of organic acids are compacted and sintered in a reducing atmosphere. Thus, Fe or Ni carbonyl is heated with the acetate of Mn, Cr, V, Mo, W, Co, or Cu to give alloy steels or alloys of Fe and Ni with these metals.

(4607) U. S. 2,122,403 (1938). C. W. Balke, F. L. Hunter and R. A. Haskell (Fansteel Metallurgical Corp.), *Hard Steel Alloy.* The alloy consists of 30-60% of Fe-group metals, 5-30% Cr, 15-50% W, Ta, Cb or Mo, and 10% TaC or CbC.

(4608) U. S. 2,152,006 (1939). E. B. Welch (Firth Sterling Steel Co.), *Articles of Hadfield Manganese Steel.* Fe and 7-20% Mn powders are mixed, pressed and sintered at 1230-1450° C. (2250-2650° F.) in a reducing atmosphere. The cold body is shaped and resintered under the same conditions to effect alloying.

(4609) U. S. 2,268,427 (1941). R. W. Schlumpf (Hughes Tool Co.), *Abrasion Resisting Ferrous Alloy.* The alloy contains Fe as major constituent with 1.5-4% C, 1-3% Mn, 0.5-2.5% Si, 3-7% Cr, 5-10% Mo, 1-3% V, and 0.5-1.5% B.

(4610) Belgian 445,601 (1942). Watt Glühlampen & Elektrizitäts A. G., *Hard Metal.* Particles of hard material, such as WC, are heated with a powdered mixture of soft Fe and finely divided C with or without alloying metals to form an alloy steel.

(4611) Brit. 555,983 (1943). Sandvikens Jernverks A. B., *Sintered Molded Bodies of Metals and Alloys.* The method of production comprises heat-treating cold-rolled or cold-drawn austenitic stainless steel to a condition in which it is susceptible to intercrystalline corrosion, subjecting it to treatment with a corroding liquid and thus causing it to disintegrate to a powder which is then processed by molding and sintering.

(4612) German 734,392 (1943). Fried. Krupp A. G., *Alloy for Cutting and Hot Working Tools.* The alloy contains 10-35% W, 2-12% Mo, 0.1-1.0% C (as elements or compounds), 3-50% Co, 3-15% Cr and up to 10% Ti, V or Ta, remainder Fe.

(4613) German 738,661 (1943). Gebr. Böhler & Co., A. G. and H. Krainer, and K. Swoboda, *Tool Alloy.* The alloy consists of 1.0-2.0% C, 0.8-2.5% V, 0.5 to less than 2% W, rest Fe.

(4614) U. S. 2,333,573 (1943). P. R. Kalischer (Westinghouse Electric & Mfg. Co.), *Steel.* Steel is produced by preparing alloying components, such as Mn or ferromanganese, ferrotungsten, ferrochrome or ferrovanadium in powders of a predetermined particle size, mixing, pressing and sintering in a carburizing atmosphere to effect a uniform distribution of a predetermined amount of C in the steel.

(4615) Swiss 230,940 (1944). J. A. Henckels, *Production of Cutting Tools.* Alloy steel powder is pressed and sintered in the form of a cutting tool.

(4616) U. S. 2,361,443 (1944). J. Wulff, *Method of Producing Ferrous Metal from Powders.* Compacted articles are made from stainless steel powder by mixing 3 different mesh sizes of powder, cold pressing and sintering in H_2.

(4617) U. S. 2,363,947 (1944). A. DeGolyer (A. Janney), *Iron-Base Alloys for Cutting Tools.* The alloy comprises 12-20% W, 1-6% Mo, 20-35% Co, 0.45-0.95% B, 0.35-0.85% C, remainder Fe and is of predetermined hardness between 62-70 Rockwell C.

(4618) U. S. 2,367,407 (1945). H. Kott (Fish-Schurman Corp.), *Abrasive Ferrous Bonding Alloy.* A wear and rust-resistant metallic composition of sintered metal powders consists of a fractional percentage of at least one of Cu, Ag, Au plus a small fractional percentage of In plus from 3-10% Mn or Ni, balance Fe containing C in the eutectoid percentage.

(4619) U. S. 2,381,674 (1945). A. Linz (Climax Molybdenum Co.), *Process of Producing Tungsten Containing Ferrous Alloys.* WO added to Fe-metal; the monoxide is then reduced and W is absorbed in the Fe metal.

(4620) Brit. 587,320 (1947). The Birmingham Small Arms Co. Ltd., S. C. Wilsdon and P. J. Ridout, *Sintered Steels.* Sintered steels are made by mixing soft Fe powder with -300 mesh Ni, Mn, and graphite, pressing at 35 tsi, and sintering at 1300° C. (2370° F.) for 1 hour.

(4621) French 936,495 (1948). Metallwerk Plansee G.m.b.H., *Material for Manufacture of Heating Appliances.* The material is made from sintered steel or alloy steel with up to 50% Ni, Cr or Al; or sintered steel impregnated with Cu.

(4622) U. S. 2,442,209 (1948). L. E. Osman (General Electric Co.), *High Temperature Alloy.* A heat treated Fe-base alloy contains 0.25-0.40% C, 16-18% Cr, 12-14% Ni, 2-4.5% W or Mo, 0.4-1% Si, 1-1.75% Mn, 0.4-1.2% Be.

(4623) Austrian 162,156 (1949). Gebr. Böhler & Co. A. G., *Production of Alloy Steels by Sintering.* During the sintering of alloy steels one or more components are present in the form of their halogen compounds; *e.g.* chromized steel is made by the addition of $CrCl_2$, or aluminized steel is made by the addition of Al halides

(4624) Austrian 163,610 (1949). Metallwerk Plansee G.m.b.H., S. Heiss and R. Kieffer, *Material for Machine Parts with High Wear Resistance.* The material is composed of sintered Fe and steel powders mixed with 30% crystals of hard carbides, *e.g.* WC or Mo_2C.

(4625) Brit. 625,397 (1949). The Birmingham Small Arms Co. Ltd., S. C. Wilsdon and P. J. Ridout, *Powdered Metal Composition.* In the manufacture of sintered steel according to Brit. 587,320 (No. 4620) the Ni content is increased to 25%, the remaining composition being unchanged.

(4626) Brit. 629,972 (1949). Metal & Plastic Compacts Ltd. and S. C. Wilsdon, *Production of Articles from Metal Powders*. Sintered Cr steel compacts made from mixed powders are prepared by chromizing the fully sintered material; the compacts stain during sintering in spite of reducing atmosphere.

(4627) Swiss 262,026 (1949). Metallwerk Plansee G.m.b.H., S. Heiss and R. Kieffer, *Material for Machine Parts with High Wear Resistance*. *Cf.:* Austrian 163,610 (No. 4624).

C. Iron Alloys (Iron-Nickel, Iron-Copper, Iron-Silicon)

(4628) U. S. 835,495 (1906). A. Bontempi (H. C. Gesner), *Alloy of Iron*. A powdered Fe-H_2 alloy is shaped, compressed, heated, in the presence of Sb, Sb sulfide, Pb or Pb acetate, and heated again to volatilize the metal. It may be dipped in paraffin to seal the pores.

(4629) Brit. 327,865 (1930). General Electric Co. Ltd., S. V. Williams and G. R. Polgreen, *Manufacture of Iron-Nickel Alloys*. Mixed oxides of Fe and Ni are reduced by heat in the presence of a reducing gas, to form an alloy.

(4630) Brit. 374,560 (1932). I. G. Farbenindustrie A. G., *Improvement in the Manufacture and Production of Metals, Metal Mixtures or Alloys*. 100 parts Fe powder obtained by thermal decomposition of Fe carbonyl and decarburized are ground in a ball mill with 25 parts anhydrous $CrCl_3$ and heated in an alumina mold, then pressed and sintered at 1000° C. (1830° F.) until diffusion is completed; the alloy contains 3.1% Cr and 96.8% Fe and is free from C.

(4631) French 741,871 (1933). Comp. Francaise Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Alloys from Iron*. Hard tenacious alloys are produced by sintering a powdered mixture of 47% Fe, 30% W, 23% Co, and less than 0.1% C.

(4632) Swiss 158,583 (1933). Heraeus-Vacuumschmelze A. G. and W. Rohn, *Method for Production of Tempering Alloys*. Alloys, especially suitable for tools with a low coefficient of expansion, are produced by mixing a powdered pre-alloy of Ni-Be with W, Mo, Cb, Ta, Ti, pressing (preferably hot), sintering for 16-24 hours at 1200-1300° C. (2190-2370° F.), and precipitation hardening by quenching from 900-1100° C. (1650-2010° F.) and back drawing at 400-500° C. (750-930° F.). A typical composition is 25-40% Ni, 8-30% W, up to 2.5% Be, balance Fe.

(4633) Brit. 419,953 (1934). Telegraph Construction & Maintenance Co. Ltd., *Manufacture of Iron-Nickel Alloys*. The process comprises heating a mixture of the oxalates of the metals in a reducing atmosphere until the reduction to metal is complete, then increasing the temperature to homogenize the alloy.

(4634) U. S. 1,942,260 (1934). H. Scott, *Alloy*. The alloy consists of Fe with 40-55% Ni and Co, and with up to 0.5% C, to obtain inflection temperatures (*i.e.* temperature ranges with a constant coefficient of expansion) of 300° C. (572° F.).

(4635) French 44,620 (1935). **(Addn.)** Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Hard Ferrous Alloys*. Supplement to French 741,871 (No. 4631). The tenacity of the alloys is increased by special heat treatment at 1500° C. (2730° F.) for several minutes followed by heating in a bath of molten Pb.

(4636) Swiss 172,424 (1935). Fried. Krupp A. G., *Body of Iron-Nickel Alloy with Very Small Coefficient of Expansion*. The body is composed of 34-39% Ni and 61-66% Fe powder, produced from their carbonyls, and sintered.

(4637) German 638,586 (1936). I. G. Farbenindustrie A. G., *Production of Metal Mixtures or Alloys*. Fe powder is mixed with Cr- or Mn-chloride and heated, to drive off the Cl and form an alloy of the Fe and Cr or Mn.

(4638) Swiss 186,604 (1936). N. V. Molybdenum Co., *Formed Bodies of Iron-Nickel-Cobalt Alloys*. The bodies are produced from a mixture of pure Fe, Ni, and Co powders which is pressed and sintered.

(4639) German 648,636 (1937). Fried. Krupp A. G., *Sintered Alloy.* A sintered alloy consists of powdered Fe carbonyls or Ni carbonyls and acetates of such metals which form alloys with the powders; the mixture is heated without a special reduction treatment to the sintering temperature.

(4640) German 675,871 (1939). Stahlwerke Röchling-Buderus A. G., *Sintered Metal Body.* A sintered metal body consisting of Fe and Ni or W with an addition of 15% of a tempering alloy of Cu and Be is pressed at 1200° C. (2190° F.), quenched and annealed at 900° C. (1650° F.).

(4641) U. S. 2,289,569 (1942). A. L. Boegehold (General Motors Corp.), *Sintered Article.* A mixture of 90% Fe powder and 10% of a powdered mixture of Ni and Si, containing 28% Si, is formed at a pressure of 50,000 psi, and then sintered at 1095° C. (2000° F.) in a non-oxidizing atmosphere.

(4642) German 740,326 (1943). Osnabrücker Kupfer & Drahtwerke, U. Raydt and W. Engelhardt, *Composite Metals.* Composites of Fe or steel with Cu, Cu alloys, Ni or Ni alloys are produced by pressing powders of the respective metals and heating them without changing their solid state.

(4643) U. S. 2,402,120 (1946). A. L. Boegehold and R. H. Terry, *Sintered Iron Article.* A porous Fe metal product is made from reduced pulverized mill scale and solid irregularly shaped Fe powder particles of small size resulting from the decarburization of a steel or cast Fe powder. The structure may be impregnated with Pb, Cu, etc.

(4644) U. S. 2,402,950 (1946). M. M. Culver and L. L. Duncan, *Molded Part.* A gasoline-controlling valve is formed of sintered Fe, and has incorporated into it by impregnation a metal, such as Pb, which closes the pores of the portions which contact liquids or gases

(4645) Brit. 586,895 (1947). Murex Ltd. and G. Miller, *Sintered Metal Products.* Hardenable Fe-Cu compacts are made by ball-milling a mixture of powders, possibly as oxide compounds, with up to 25% Cu. They are amalgamated at 600° C. (1110° F.), using a high pressure either before or during the sintering which occurs below 1150° C. (2200° F.) with the Cu present as a liquid phase.

(4646) Brit. 588,814 (1947). General Electric Co. Ltd., *Heat-Resisting Alloy.* A composition of 8% Ni, 20% Cr, 4% W, 68% Fe in powdered form is mixed and compressed in molds at a pressure of 30 tsi for 30 hours at 1350° C. (2460° F.) in a non-oxidizing atmosphere.

(4647) Brit. Appl. 34528/47 (1947). D. Primavesi, *Iron-Antimony Alloy.* An Fe alloy with 14% Sb is made from the elemental powders which are sintered at 1000° C. (1830° F.) and then cold or hot worked.

(4648) Brit. Appl. 19463/48 (1948). D. Primavesi, *Production of Sintered Alloys.* The properties of sintered Fe-Cu and Fe-C alloys are compared with their cast equivalents; specifically, sintered Fe with 14.5% Cu is covered, but the methods of manufacture are not described.

(4649) Brit. Appl. 28355/48 (1948). American Electro Metal Corp., *Composite Shaped Bodies.* Gas turbine blades are made by heat-treating sintered porous Fe impregnated with molten Cu alloy.

(4650) Brit. Appl. 30790/48 (1948). American Electro Metal Corp., *Parts for Jet Propulsion Engines.* The parts are made from sintered Fe impregnated with Cu and coated with an Sn or Zn alloy for improved corrosion resistance.

(4651) Brit. Appl. 30959/48; 9930/49 (1948). American Electro Metal Corp., *Coating Metal Articles with Aluminum Alloys.* Turbine blades of sintered Fe, impregnated with Cu, are coated with Al by hot dipping. They are then precipitation hardened.

(4652) Brit. Appl. 32717/48 (1948). D. Primavesi, *Sintered Alloy.* It is claimed that Cu can be substituted for C in Fe-C systems. A sintered alloy of 92.5% Fe, 4.5% Ni, 3% Cu has tensile strength of 102,000 psi.

(4653) Austrian 162,880 (1949). Gebr. Böhler & Co., A. G., *Sintered Iron Bodies.* Bodies with low porosity, high hardness and good slip quality are produced from powders of Fe mixed with Ca ferrite.

(4654) Austrian 163,408 (1949). Metallwerk Plansee G.m.b.H., *Unannealed*

Sintered Body with Great Toughness. Fe powder is mixed with 1-5% Al and sintered.

(4655) Austrian 163,626 (1949). Metallwerk Plansee G.m.b.H. and R. Kieffer, *Production of Formed Bodies of Iron-Silicon Alloys.* Porous Fe skeletons are impregnated with Si or Si alloys.

(4656) Brit. Appl. 96/49 (1949). D. Primavesi, *Process for Fabricating Metal Articles.* Articles from Fe or Fe alloys are produced from metal compounds, mainly chlorides, such as $FeCl_2$ + CuCl or $MnCl_2$, and pressed and sintered alone or mixed with metal powders. Alternatively, the metal compounds may be die-cast at lower temperatures than the respective metals.

6. NON-FERROUS MATERIALS AND PRODUCTS

A. Copper and Copper Alloys

(4657) U. S. 1,661,245 (1928). H. M. Williams (General Motors Research Corp.), *Bearing Composition.* The composition consists of 77% Cu, 4.5% Sn, 13.5% Sb-Sn, and 5% graphite.

(4658) German 473,376 (1929). Gebr. Siemens & Co., *Production of Formed Bodies of Copper.* A mass of Cu is produced from a dilute solution by electrolysis with high current density, and the precipitate is reduced in H_2; the resulting powder is compacted and heated in H_2.

(4659) U. S. 1,748,037 (1930). E. J. Leach (Ackermite Co.), *Bearing.* The bearing consists of a matrix of Cu having Pb embedded therein plus a cold compacted thin, smooth, wear-resisting inner surface of Pb.

(4660) U. S. 2,096,252 (1937). R. P. Koehring (General Motors Co.), *Copper-Lead Bearing Materials.* Cu powder is pressed to shape, sintered, and then heated above the melting point of Pb in contact with Pb, so that the voids are filled in the sintered bearing, and a dense product results.

(4661) U. S. 2,102,238 (1937). N. B. Pilling and P. D. Merica (International Nickel Co.), *Alloy of Copper-Nickel-Titanium.* A hard alloy containing 2-50% Ni, 1-10% Ti, and Cu as balance is produced by heating to a temperature below the melting point but high enough to cause the Ti to go into solution; quenching, reheating to a temperature below that of initial heating, but sufficient to obtain an increase in the hardness of the alloy.

(4662) French 835,468 (1938). Alloys Ltd., *Copper-Titanium Alloy.* Cu hydride and Ti hydride are mixed and heated to decompose the Ti hydride; then the temperature is raised to alloy the Cu with the Ti.

(4663) Australian 107,169 (1939). General Motors Corp., Holdens Ltd. and A. L. Boegehold, *Bearing Metal Alloy.* The alloy consists of Cu plus Ni, with an alloy of Sb-Sn filling the pores.

(4664) Brit. 503,874 (1939). W. D. Jones, *Manufacture of Metal Articles.* The manufacture of metal articles from bronze metal powders, mixed with Ca-, Ti-, or Zr-hydride, involves the application of heat and, if desired, pressure, to the mixed powders.

(4665) German 677,231 (1939). Hardy Metallurgical Comp., *Bearings.* A method of producing bearings from metals, *e.g.* Pb and Cu, which do not alloy easily, comprises making the core from particles of the metal which has the lower melting point, which are coated with the metal with the higher melting point; the particles are pressed and sintered at a temperature between the two melting points.

(4666) U. S. 2,196,875 (1940). L. Sandler and L. G. Klinker (Johnson Bronze Co.), *Bronze Bearing and Method of Manufacture.* Sintered dense bearings are composed of 25-90% of pre-cast Pb-bearing bronze and a binder metal, such as Cu, Sn, Al, Zn, in solid solution in the bronze.

(4667) Brit. 531,389 (1941). A. L. Woodworth, *Bullets*. A bullet is formed of a porous sintered metal powder mixture in which Cu particles are bound together by intimately mixed particles of another powdered metal of a lowing melting point, *e.g.* Sn; the powders are compressed and sintered below the melting point of Cu in a reducing atmosphere.

(4668) Brit. 541,471 (1941). Mallory Metallurgical Products Ltd., *Bearings*. A bearing material comprises a matrix of sintered and bonded metallic particles, such as Cu, plus a hardening ingredient, which is an inter-metallic compound, forming a coherent pressure resisting structure.

(4669) U. S. 2,246,462 (1941). E. R. Darby (Federal Mogul Corp.), *Bearing Alloy*. A dense bearing alloy has a Cu base and embedded particles of Pb.

(4670) German 716,932 (1942). Heraeus Vacuumschmelze and W. Hessenbruch, *Bearing Material*. A dense Cu-Pb alloy is produced by saturating a porous, sintered body of Cu with molten Pb.

(4671) German 717,454 (1942). General Motors Corp. and A. L. Boegehold, *Bearing*. A bearing has a porous Cu-base body soaked with a molten alloy of Pb with 2-15% Sb and 2-15% Sn.

(4672) U. S. 2,289,571 (1942). A. L. Boegehold (General Motors Corp.), *Dense Sintered Article and Method of Making Same*. A briquetted and sintered bronze article is produced from a Cu-Sn alloy powder mixed with Cu powder.

(4673) U. S. 2,331,909 (1943). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Gear*. The toothed surface of a gear is formed of a compact bonded mass of Cu alloy powders containing precipitation-hardening intermetallic compounds in a disperse phase, and imparting to the surface a greater hardness than the core of the Cu alloy has.

(4674) U. S. 2,338,344 (1944). A. J. Marino (P. R. Mallory & Co. Inc.), *Tungsten-Bronze Articles, such as Governor Weights*. Articles having a density substantially equal to that of wrought bronze free from W are formed by mixing and sintering a mixture of metal powders, such as 90.5% Cu, 5% Sn and 4.5% W.

(4675) U. S. 2,362,007 (1944). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Method of Making Sintered Copper-Chromium Metal Composition*. The process comprises mixing powders to form a mixture containing Cu, Cr, P and a metal hydride, then pressing and sintering.

(4676) U. S. 2,368,943 (1945). R. L. Patterson (New Jersey Zinc Co.), *Powder Metallurgy of Brass*. The production of brass objects comprises compressing metal powders containing 90-55% Cu, 0.1-1% P, balance Zn.

(4677) U. S. 2,379,434 (1945). F. R. Hensel (P. R. Mallory & Co. Inc.), *Bearing*. A bearing is formed from metal powders of Cu and Tl.

(4678) U. S. 2,379,435 (1945). F. R. Hensel (P. R. Mallory & Co. Inc.), *Bearing*. A bearing is formed from metal powders composed of Cu, Pb, and Tl.

(4679) U. S. 2,381,497 (1945). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Antifriction Alloy*. A cu-base alloy contains 1-35% Pb and 0.01-10% of a metal selected from the group consisting of U and Th.

(4680) U. S. 2,389,438 (1945). H. A. Knox, *Track Shoe*. A track shoe uses a metal bushing made from powdered bronze mixed with a ferrous material.

(4681) Brit. 577,798 (1946). Manganese Bronze & Brass Co. Ltd., *Sintered Metal Composition*. A material used for bushes and bearing-linings is made by mixing an alloy of Sn and Pb with powdered Cu, pressing and sintering, so that the segregation of Pb during sintering is avoided.

(4682) U. S. 2,393,906 (1946). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Metal Composition and Bearing Characterized by High Strength*. The bearing is formed of a sintered and age-hardened metal composition containing 0.5 to 5% Ni, 0.1-1% P, balance Cu.

(4683) Brit. 586,210 (1947). Mallory Metallurgical Products Co., *Bearings of Copper Base Sintered Metal Composition*. Cu bearings containing Ni-silicide or Co-silicide are improved by adding a small amount of P.

(4684) Brit. Appl. 34531/47 (1947). D. Primavesi, *Sintered Bronze.* Al bronze compacts are made by treating a mixture of Cu-Al powders with 0.5-2% Ti in an eccentrically mounted ball mill. The powders are pressed and sintered in H_2 atmosphere at a temperature sufficient for the formation of Ti-hydride.

(4685) Brit. 600,156 (1948). Glacier Metal Co. Ltd. and W. B. D. Brown, *Engine Cylinder.* Cylinder liners of sintered Pb bronze with a composition of 10% Sn, 10% Pb, balance Cu, are claimed to be corrosion-resistant and have low friction.

(4686) U. S. 2,447,979 (1948). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Copper Base Alloy for Metal Evaporation.* An alloy loop for metal evaporation is composed of 0.001-1% Li, 0.25-20% Pt and Pd, balance Cu.

B. Nickel, Cobalt, Manganese and their Alloys

(4687) Swiss 43,908 (1908). Siemens & Halske A. G., *Homogeneous, Ductile Mass.* Ni and a metal of the Cr-group are mixed in the powdered state with paraffin and heated till a homogeneous ductile mass results.

(4688) Austrian 106,973 (1927). A. P. Kurt, *Molded Acid-Resisting Articles of Sintered Nickel-Base Hard Alloys.* The articles are prepared by fusing in a mold at 1700-1800° C. (3090-3270° F.) a powdered mixture of Ni, Mo, plus B or Ti, and C from B_6C.

(4689) Canadian 273,209 (1927). W. A. Wissler, *Nickel Alloy for Metal Cutting Tool.* An alloy for cutting tools is produced from powders composed of 15-40% Cr, 15-35% W, 0.5-2.5% B, 0.75-2.5% C, and remainder Ni.

(4690) U. S. 1,636,763 (1927). H. Boving (Western Electric Co.), *Metallic Composition.* An alloy of Ni and Ba is produced by molding a mixture of the metal powders in the presence of gas under pressure sufficient to hinder the volatization of Ba, and increasing the temperature to form an alloy.

(4691) Brit. 293,727 (1928). General Electric Co. Ltd., *Manufacture of Alloys of Nickel and Chromium.* 70% Ni and 30% Cr powder are mixed, pressed in a steel die, and placed in a refractory body of sillimanite or magnesite, then heated in pure H_2 until the metals begin to melt.

(4692) Swiss 138,072 (1930). I. G. Farbenindustrie A. G., *Method of Production of Bodies from Metal Powders.* Metal powders of Ni produced from carbonyls are either pressed to the desired shape and then sintered and worked to wire, sheet, etc. of highest purity, or simply poured into molds and settled to a close packing, followed by sintering into porous bodies (*e.g.* Ni filters).

(4693) U. S. S. R. 29,253 (1931). I. A. Putvirskii, Yu. P. Biryukov, and I. S. Brokhin, *Hard Nickel Alloy.* The sintered alloy consists of 20-50% Ni, 10-20% W, 20-35% Cr, 5-25% Fe, and 1-5% C.

(4694) Austrian 135,669 (1933). A. P. Kurt, *Molded Acid-Resisting Articles.* The articles are prepared by fusing in a mold a powdered mixture of Ni plus Mo containing 2-12% B or Ti plus C.

(4695) U. S. 1,924,244; 1,924,245 (1933). W. Köster (Vereinigte Stahlwerke A.G.), *Process for Improving Nickel-Tin Alloys.* A hard alloy of 5-25% Sn, balance Ni, is produced by heating to a temperature lying between 900° C. (1650° F.) and the melting point of the alloy, and annealing at a temperature between 400 and 800° C. (750 and 1470° F.).

(4696) Austrian 139,674 (1934). N. V. Molybdenum Co., *Discharging Device.* The device has an electrode of 15-40% Mo, 10-30% Fe, remainder Ni.

(4697) French 762,044 (1934). Soc. Industrielle et Commerciale des Aciers, *An Alloy Formed by Precipitation Hardening.* A mixture of 10-30% Fe, 2-12% W, 2-12% Mo, 25% Co, up to 10% of Ti, V, or Ta, balance Ni, is sintered at 1350° C. (2460° F.), then quenched and annealed at 800° C. (1470° F.).

(4698) French 45,987 (Add.) (1936). Comp. Française Pour L'Exploitation Des Procédés Thomson-Houston, *Fritted Hard Alloy for Tools.* Addition to French

741,871 (No. 4631). Mixtures containing 5-30% Mo, 95-70% Co, and less than 0.1% C are sintered and heat-treated.

(4699) German 662,791 (1938). I. G. Farbenindustrie A. G. and G. Hamprecht, *Sintered Nickel.* Ni of great strength is obtained by sintering Ni powder from the decomposition of $Ni(CO)_4$ with 0.1% C and mixed with some Mn.

(4700) U. S. 2,159,231 (1939). L. Schlecht and W. Schubardt (I. G. Farbenindustrie A. G.), *Articles Such as Sheets of Nickel Alloys.* Ni alloy articles containing not more than 0.3% Cu are produced by hot pressing a mixture of Ni powder, obtained by thermal decomposition of $Ni(CO)_4$, and Fe, Cr, Cu, or Mn powder.

(4701) U. S. 2,159,604 (1939). L. Schlecht and W. Schubardt (I. G. Farbenindustrie A. G.), *Process of Producing Nickel Articles.* Ni articles containing not more than 0.03% C are made by hot pressing to sintering temperature; the Ni powder is obtained by thermal decomposition of $Ni(CO)_4$.

(4702) U. S. 2,291,685 (1942). H. A. Brassert (Minerals & Metals Corp.), *Manufacture of Manganese, and its Alloys.* An oxide of Mn is reduced, compressed at the temperature of residual heat of reduction, heated to a higher temperature in a non-oxidizing atmosphere and further compressed to provide the material with a surface substantially impenetrable to oxidation gases.

(4703) U. S. 2,432,149 (1947). W. T. Griffith and L. B. Pfeil (International Nickel Co.), *Heat Resistant Nickel Alloy.* A heat resistant alloy comprises 10-30% Cr, 0.001-0.5% alkaline earth metal, 0.01-0.5% Th, balance Ni.

(4704) U. S. 2,441,126 (1948). J. Kurtz (Callite Tungsten Corp.), *Oxidation Resistant Alloy.* An alloy of Ni, Cr, Cu, Ag is produced by combining a powdered mixture of 90% Ni and 10% Cr with a mixture of 70% Ni and 30% Cu, then adding 75-96% of these combined powders to 25-4% Ag powder, and pressing and sintering the mixture.

(4705) U. S. 2,471,630 (1949). J. Kurtz (Callite Tungsten Corp.), *Pressed and Sintered Oxidation Resistant Nickel Alloys.* The pressed and sintered oxidation resistant alloy consists of 64.8% Ni, 24.3% Cu, 0.9% Cr and 10% Ag; the constituents are thoroughly diffused and free from Cr oxide inclusions.

C. Low-Melting Precious Metals and Alloys (Gold, Silver)

(4706) Brit. 541,228 (1941). Mallory Metallurgical Products Ltd., *Bearings.* The bearings consist of a compact bonded or a pressed and sintered mass of Ag interspersed with Pb, or one of the low melting bearing metals or alloys, such as Pb alloy, Zn, Sn, Cd, babbitt, or white bearing alloys of Al, Sb, Bi, Tl.

(4707) U. S. 2,377,882 (1945). F. R. Hensel and E. I. Larsen (P. R. Mallory and Co. Inc.), *Bearing.* The bearing is produced from relatively coarse Ag powder.

D. Light Metals and Alloys

(4708) German 425,451; 425,452 (1926). E. Schmid, *Production of Articles of Aluminum.* The bodies are produced by pressing Al powder and then heating in N_2 atmosphere close to the melting point of Al.

(4709) U. S. 1,775,589 (1930). H. S. Cooper (Beryllium Corp. of America), *Products of Beryllium.* Comminuted Be is pressed into a coherent body and then fused under nonreactive molten flux.

(4710) U. S. 1,944,183 (1934). L. W. Kempf and I. R. Dawson (Aluminum Co. of America), *Alloy.* High-Si alloys of Al are produced by hot-pressing -40 mesh or -90 mesh powder from 200° C. (390° F.) to just below the temperature at which the lowest-melting constituent melts.

(4711) U. S. 2,024,767 (1935). Z. Jeffries and L. W. Kempf (Aluminum Co. of America), *Pistons and Method of Making Same.* Pistons are manufactured from Al and Si powders, mixed in a 75-25 ratio.

(4712) German 630,710 (1936). Österreichisch-Amerikanische Magnesit A. G., *Magnesium.* Mg powder is converted into block form by pressing and heating.

(4713) German 641,140 (1936). Metallgesellschaft A. G., *Permanent Mold.* A permanent mold for metal casting consists of an alloy of sintered Al-Si.

(4714) U. S. 2,122,139 (1938). F. Hansgirg (American Magnesium Metals Corp.), *Compact Metallic Magnesium.* Powdered Mg is mixed with an electrically conducting material such as C and with MgO and oil as a binder, pressed, and then an electric current is passed through the body.

(4715) German 673,505 (1939). F. Skaupy, *Production of Compact Metal Bodies of Light Metals.* The removal of oxide coatings of metals such as Al during sintering is brought about by adding small quantities of chlorides or fluorides to the powdered constituents.

(4716) Brit. 522,463 (1940). Deutsche Gold- & Silberscheideanstalt, *A Process for the Production of Sintered Bodies of Light Metals.* Al, Mg, or Be alloys are pressed and sintered in a reducing atmosphere with the addition of soldering powder fluxes which remain behind in the product.

(4717) Brit. 527,618 (1940). Deutsche Gold- & Silberscheideanstalt, *Sintered Bodies of Light Metals.* A light metal alloy powder is provided with a metallic coating by galvanic means.

(4718) French 856,411; 856,598 (1940). Deutsche Gold- & Silberscheideanstalt, *Production of Sintered Bodies of Aluminum.* The Al powder is first galvanized with Cu, Sn, Zn, Fe, or the powder is mixed with carbonates or borates; the combined reducing and sintering step occurs at 500° C. (930° F.).

(4719) U. S. 2,219,095 (1940). P. Schüttler, *Light Metal Piston Rings for Internal Combustion Engines. Cf.:* German 734,599 (No. 4726).

(4720) Brit. 539,516 (1941). W. B. Hamilton, *Converting Powdered Magnesium Into Coherent Form.* Blocks of Mg are produced by pressing and heating them in the induction field of a high frequency furnace at a temperature below the vaporization temperature.

(4721) German 704,517 (1941). Deutsche Gold- & Silberscheideanstalt, *Formed Body of Beryllium.* A body of Be is produced from the powder by agitating it with concentrated H_2SO_4, then mixing with a liquid of high specific gravity and then pressing and sintering.

(4722) German 705,886 (1941). P. Schüttler, *Light Metal Piston Rings for Internal Combustion Engines.* Piston rings are made from powdered light metals to which is added a powdered heavy metal. The powders are intimately mixed and sintered under high pressure. The sintered ring is subsequently oxidized electrolytically.

(4723) U. S. 2,287,251 (1942). W. D. Jones, *Non-Porous Articles from Aluminum.* Alloys of high tensile strength, density and elongation contain 1.5-6% Mg, 2-3.5% Mn, up to 5% Si, up to 1% Sb, balance Al, and are cold-pressed above 5 tsi, then hot-pressed at 400-600° C. (750-1110° F.).

(4724) U. S. 2,294,405 (1942). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co.), *Aluminum-Base Metal Composition.* The alloy is composed of 1-40% Cd, 1-40% C, 50-90% Al and is sintered and bonded.

(4725) German 730,786 (1943). Kabelwerk Vacha A. G., *Light Metal Coating.* Grains of Al are coated with Pb and then the mass is squirted out of a press to form a mantle for cables.

(4726) German 734,599 (1943). P. Schüttler, *Light Metal Piston Rings for Internal Combustion Engines.* Improvement of German 705,886 (No. 4722). Up to 30% Co is added to the previous mixture; a typical composition is 10-30% Co, 2-5% Ni, 1-4% Mg, 2-5% Cr, and remainder Al.

(4727) German 748,494 (1944). W. Dawihl, *Manufacture of Sintered Articles from Aluminum.* Al powder is sintered into articles by first hot-pressing, then sintering and forging, either cold or hot.

(4728) U. S. 2,361,925 (1944). H. A. Brassert and J. C. Hartley (Minerals & Metals Corp.), *Preparation of Magnesium Products.* The method comprises reducing MgO in the finely divided state to metallic Mg, compacting the Mg into dense tablets while still in a freshly reduced condition, and coating the tablets with a substantially impervious material which is inert with respect to Mg.

(4729) U. S. 2,367,020 (1945). F. Hansgirg (North Carolina Magnesium Development Co.), *Treatment of Metallic Materials.* A method of dry pelleting Mg comprises particles which are coated with a carbonaceous material, heating the powder to the temperature at which the particles become plastic, and compressing them into solid compacts.

(4730) U. S. 2,383,026 (1945). J. A. Toleik, *Aluminum Alloy.* One method of preparing an alloy of Al with small percentages of 11 other, higher melting materials, comprises adding of the ingredients in powdered form and melting in a crucible.

(4731) Brit. 584,960 (1947). Howlett & Wellworthy Piston Ring Ltd., *Aluminum Alloys.* An Al alloy is produced by hot pressing or sintering in vacuum.

(4732) Brit. 595,214 (1947). E. I. Brimelow and N. Dudzinski, *Aluminum Alloy.* An Al-Si eutectic alloy of low thermal coefficient of expansion and suitable for pistons is produced by powder metallurgy methods.

(4733) Brit. Appl. 18835/47 (1947). S. A. Pour L'Industrie de L'Aluminium, *Light Metal Bodies.* Aluminum powder is pressed at 12 tsi and then hot-pressed at 600° C. (1110° F.) and 38 tsi to make sintered pistons.

(4734) U. S. 2,418,881 (1947). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Sintered Aluminum Bearings.* Bearings are formed of an alloy composed of 0.5-45% Tl, balance Al and have a low coefficient of friction and good corrosion resistance.

(4735) Swiss 250,118 (1948). Aluminium Industrie A.G., *Production of Light Metal Bodies.* At least 50% of the light metal powder, which is to be pressed, has a grain size smaller than 2 μ.

(4736) Brit. 625,364 (1949). S. A. Pour L'Industrie de L'Aluminium, *Manufacture of Light Metal Bodies.* The bodies are manufactured by pressing and sintering Al flake powder.

(4737) Brit. 626,764 (1949). American Electro Metal Corp., *Producing Shaped Bodies from Powdered Aluminum.* Al powder of 325 mesh size and containing 99.5% metallic Al is mixed and bonded with 2-40% powdered Duralumin, and a non-oxidizing pressing lubricant, then compacted at 40 tsi, sintered in air at 600° C. (1110° F.) for 1 hr. and quenched. Upon sintering of the compacted powder, the lower melting Duralumin films form a cement, and the resulting non-equilibrium structure combines high strength with good ductility.

E. Low-Melting Metals and Alloys

(4738) Australian 23,416 (1935). E. Gilbert, *Sintered Bearing Material.* The resistance to corrosion of sintered bearing material is improved by adding salts of H_2CrO_4; *e.g.*, 98-100 parts Cd, and 0.5-5 parts Ni are mixed with 1-5% $CoCrO_4$.

(4739) U. S. 2,102,998 (1937). P. J. Potter and E. R. Darby (Federal Mogul Corp.), *Linter for Bearings.* A bearing metal alloy consists of 58% Cd, 15% Zn, 25% Pb, 1% Cu and 1% Ag.

(4740) U. S. 2,149,782 (1939). R. Lucas, *Magnetizable Fluid.* A magnetizable Hg indicating fluid for use in measuring instruments is composed of 14% steel dust, 3% graphite and 83% Hg.

(4741) U. S. 2,156,802 (1939). H. S. Cooper (Cooper Products Inc.), *Method of Making Lead Alloys for Bearings.* Pb alloys are made from a mixture consisting of 30-70% PbO_2 and 70-30% CuO, in which the Pb is uniformly distributed; the mixture is reduced at 500° C. (930° F.), then compressed and sintered.

(4742) U. S. 2,325,071 (1943). W. S. Murray (Indium Corp. of America), *Use of Lead-Indium Particles in Bearings Such as Those of Aircraft Engines.* A surface layer of finely divided Pb-In particles is placed on a steel support and heated to bond together.

(4743) U. S. 2,428,959 (1947). E. J. Boyle and E. A. Anderson (The New Jersey Zinc Co.), *Zinc-Titanium-Manganese Alloys.* A Zn-base alloy containing 97% Zn, 0.01-1.6% Ti, 0.05-1.5% Mn, is characterized by high creep resistance and is produced from powders.

7. POROUS PRODUCTS

A. Bearings and Bushings

i. Copper-Base (Bronze)

(4744) U. S. 101,861; 101,862; 101,863; 101,864; 101,865; 101,866; 101,867; 101,868; 101,869 (1870). S. Gwynn (American Metalline Co.), *Composition of Matter Called Metaline for Journals, Bearings, etc.* "Metalline #1-8" is composed of powder ingredients or their equivalents by the process and for the anti-friction purpose set forth."

(4745) U. S. 122,408 (1872). W. H. Saunders, *Alloys for Preventing Friction.* An antifriction metal is made from Fe filings alloyed with resin, tar, glass, Zn, Sb and Pb.

(4746) U. S. 138,641; 138,642; 138,643; 138,644; 138,645; 138,646 (1873). S. Gwynn (American Metalline Co.), *Journal-Box Linings.* Powdered "metaline" as described in U. S. 101,861/9 (No. 4744) is compacted by filling it into grooves, perforations or corrugations in a sheet of Cu or brass, or into metal tubes, and then subjecting to pressure; or sheets of fabric or wood are laminated with metaline between the layers.

(4747) U. S. 189,684 (1877). G. E. Behrens (J. Smalley and O. B. Reynolds), *Anti-Friction Compounds.* A metal or alloy is intimately mixed with plumbago, or graphite, placed in a die and pressed.

(4748) U. S. 304,500 (1884). F. E. Canda, *Solidified Compound Metals.* The bodies are produced by mixing metal or alloy powders, such as Cu or bronze whose particles are coated with Sn or Babbitt metal, molding the mixture with a flux, heating and pressing into shape.

(4749) U. S. 313,916 (1884). F. E. Canda, *Anti-Friction Material and Journal or Other Bearing.* An anti-friction bearing lining is produced by placing the bearing shell in a die, adding pulverized material, and subjecting the bearing and lining to heat and pressure.

(4750) U. S. 379,531 (1888). J. Douglas, Jr. (North American Metalline Co.), *Bearings.* An antifriction composition is produced by milling at elevated temperatures, *e.g.* 100° C. (212° F.), a mixture of Cu and Sn or Pb and Sn with S to form metallic sulfides, adding graphite and paraffin to the resulting powders, and pressing the mixture.

(4751) French 349,459 (1905). L. Boudreaux, *Porous Copper-Base Bearings.* The Cu powder is produced by reduction of CuO, condensation of the metal vapors, precipitation, or electrolysis; the powders are heated in the loose or compacted state under a protective atmosphere.

(4752) U. S. 857,845 (1907). D. H. Stewart, *Journal-Bearing.* Journal bearings are produced by compressing lubricant-coated, shredded, antifriction bearing metal.

(4753) Brit. 25,909/1909 (1910). V. Löwendahl, *Porous Metal Blocks.* Powdered Cu, Sn, Zn, Al are sintered to produce bearings and brushes.

(4754) German 218,887 (1910). V. Löwendahl, *Production of Porous Bodies.* Metal powders, *e.g.*, Cu and Zn, are mixed with volatilizable powders, *e.g.*, NH_4NO_3, pressed and sintered; the pores are then filled with a lubricant by pressing or sucking in.

(4755) U. S. 1,071,044 (1913). E. G. Gilson (General Electric Co.), *Process of Making Bearing Compositions.* Porous bearing compositions are made by partially reducing a mixture of graphite, CuO and SnO_2, compressing, and reheating at reducing temperature.

(4756) U. S. 1,177,407 (1916). E. G. Gilson (General Electric Co.), *Bearing Material Suitable for Internal Combustion Engines.* A self-lubricating bearing is composed of 73% Cu, 13% Sn, 10% Pb and 4% graphite, and is prepared by mixing, reducing, compressing and sintering.

(4757) Brit. 163,809 (1921). F. L. Ball and L. W. Tools Co. Ltd., *Bearings.* The lining of the bearing consists of pressed metal powders or granules, produced by stirring a bath of molten metal, whose surface is covered with finely divided graphite.

(4758) U. S. 1,479,859 (1924). W. Koehler, *Process for Making Anti-Friction Metal.* The process comprises mixing finely comminuted metals of different melting points, *e.g.*, Cu and Sn, and subjecting the mixture to a temperature sufficiently high to melt the metal having the lowest melting point.

(4759) Brit. 210,063 (1925). General Motors Research Corp., H. M. Williams and A. L. Boegehold, *Porous Metal Bearings.* The bearings consist of a metal powder, *e.g.* 90/10 Cu/Sn, and graphite, talc, mica, etc.; the compressed mixture is sintered with a volatile flux.

(4760) Brit. 214,580 (1925). General Motors Research Corp., A. L. Boegehold and H. M. Williams, *Improvements in or Relating to Bearing Materials.* Cu-Sn together with $MgCO_3$ is compressed and heated in a non-oxidizing atmosphere to cause the decomposition of the carbonate and alloy the metals.

(4761) Brit. 216,484 (1925). General Motors Research Corp. and H. M. Williams, *Improvements in or Relating to Alloy Articles.* A porous bronze bearing is obtained by forming a metallic compound mixture, *e.g.* 77% Cu, 4.5% Sn, 13.5% SnSb and 5% C, reducing this mixture to a fine state of subdivision, molding it under high pressure and heating the molded article to induce the alloying of the constituents, so that the SnSb grains are embedded in a softer matrix of bronze. Cu_3Sn or Cu_3Sb may be used in place of SnSb.

(4762) Brit. 230,896 (1925). General Motors Research Corp. and A. E. White, *Improvement in Metallic Materials.* Self-lubricating bearings are produced by mixing finely divided Cu, Sn in a ratio of 90 to 10 and salicylic acid, pressing and heating the body to 675° C. (1245° F.) in a non-oxidizing atmosphere to drive off the acid and then alloying the metals, to produce oil-less bearings having an interconnected porosity.

(4763) U. S. 1,556,658 (1925). H. M. Williams, *Bearings of Copper, Tin and Graphite.* The powdered constituents are compressed, packed in lampblack in a sealed container and sintered at 590-760° C. (1090-1400° F.) for 5-7 hours.

(4764) German 432,063 (1926). General Motors Research Corp., *Porous Bearing. Cf.:* Brit. 230,896 (No. 4762).

(4765) German 437,019 (1926). General Motors Research Corp., *Production of Alloys for Porous Bearings.* A mixture of 90 parts Cu, 10 parts Sn, 6 parts mica, and 0.53 parts NH_4Cl is pressed, packed in graphite and heated in a non-oxidizing atmosphere to alloy the ingredients.

(4766) U. S. 1,607,389 (1926). C. Claus (Bound Brook Oil-Less Bearing Co.), *Pressed Metal Articles.* The production of bearings or bushings from powdered Cu-base alloys involves compressing them to a porous body with a smooth, lustrous surface; then heat treating the body to provide a coherent mass. The products are then soaked in oil and subjected to the action of a set of sizing dies.

(4767) Brit. 275,444 (1927). C. Claus, *Compressed Composition for Bearings.* A fine mixture of 80-90% Cu, 7-14% Sn, 2-3% Zn, 2-6% graphite is pressed and sintered.

(4768) German 442,374 (1927). General Motors Research Corp., *Porous Bearings.* Porous bearings are made of powdered Cu-Sn metals with an addition of $MgCO_3$ whose decomposition during sintering sets free gases not corrosive to the metal and a residue that is fit as a filling material.

(4769) U. S. 1,642,347; 1,642,348; 1,642,349 (1927). H. M. Williams and A. L. Boegehold (General Motors Research Corp.), *Porous Alloy Structure.* Metal powders, such as Cu and Sn plus a volatile material, *e.g.*, salicylic acid, talc, $MgCO_3$ are mixed and sintered, leaving a porous body.

(4770) Brit. 284,532 (1928). General Motors Research Corp. and A. E. White, *Porous Metals.* Bearings containing Cu, Sn, Pb, C are made by powder metallurgy methods. Porosity of controlled characteristics is obtained by admixing to the powder salicylic acid which volatilizes during sintering.

(4771) French 636,124 (1928). General Motors Research Corp., *Porous Metallic Bodies.* Porous bearings are produced by sintering pressed mixtures of powdered Cu, Pb, graphite, Sn-phosphide and salicylic acid.

(4772) German 466,514; 467,843 (1928). Gebr. Siemens & Co., *Production of Bearings.* Bearings are produced from Cu and C by intimately mixing the powdered constituents before reduction.

(4773) U. S. 1,738,163 (1929). H. M. Williams (General Motors Research Corp.), *Porous Metal Bearings.* Powdered Cu, Pb and a deoxidizer, such as P-Sn is compressed and sintered above the melting point of Pb, but below that of Cu.

(4774) U. S. 1,753,581 (1930). R. L. Seabury (Delco-Remy Corp.), *Bearing.* A bearing is produced by baking in a mold a mixture of metal powders, electroplating them with Cu or brass, and immersing the porous product in lubricating oil.

(4775) U. S. 1,761,506 (1930). H. M. Williams (General Motors Research Corp.), *Method of Making Articles of Lead-Copper and Analogous Alloys.* A bearing composed of a homogeneous mixture of Cu plus Pb is produced by compressing and heating porous blanks in a non-oxidizing atmosphere.

(4776) U. S. 1,768,528; 1,768,529 (1930). C. R. Short (Moraine Products Corp.), *Manufacture of Bearings.* Bronze powder is used as a base for the processing of porous bearings.

(4777) French 715,478 (1931). Westinghouse Electric & Mfg. Co., *Bearing with Slight Friction.* 48 parts of Cu, 10 parts of Zn, and 5 parts of Pb are mixed with 2.5 parts of stearic acid and 2 parts graphite, pressed and heated.

(4778) German 524,032 (1931). General Motors Research Corp., *Production of Porous Lead-Containing Bodies for Bearings.* Cu and Pb powder is mixed before sintering with P-Sn, which serves as an agent for deoxidation.

(4779) U. S. 1,819,272 (1931). C. R. Short (Moraine Products Co.), *Bimetallic Bearings.* A porous metallic lining of Cu-Sn is attached to a denser metal (*e.g.*, Fe) reinforcing member by holding the elements in direct contact and heating to a high temperature.

(4780) Brit. 365,068 (1932). C. F. Sherwood, *Porous Metal Articles, such as Bearings, Brake Linings etc., from Powdered Metals.* A solid volatilizable lubricant, such as stearic acid, is dissolved in ether, and mixed with powdered metals such as Cu-Sn. During sintering the volatile solvent evaporates, leaving a coating of lubricant on the metal.

(4781) U. S. 1,871,912 (1932). E. S. Patch (Moraine Products Co.), *Piston for Liquid Meters.* A piston for a liquid meter has a bearing surface formed of porous bronze impregnated with lubricant.

(4782) U. S. 1,873,223 (1932). C. F. Sherwood (Sherwood Patents Ltd.), *Porous Bodies, Such as Bearings from Powdered Metals. Cf.:* Brit. 365,068 (No. 4780).

(4783) German 581,425 (1933). Bound Brook Oilless Bearing Co., *Self-Lubricating Bearings.* Alloys for making bearings are composed 85% Cu, 9% Sn, 2% Zn, 4% graphite and sintered at a temperature of 750-800° C. (1380-1470° F.), for 10-20 minutes.

(4784) U. S. 1,922,402 (1933). C. R. Short (Moraine Products Co.), *Method of Sintering Briquetted Materials.* A mixture of 90% Cu, 10% Sn, 6% salicylic acid,

and 0.53% NH_4Cl is briquetted into the form of bearing bushings under high pressure, then heated to a temperature near a predetermined sintering temperature; the hot product is then immediately passed into the sintering zone.

(4785) U. S. 1,930,287 (1933). C. R. Short and C. V. Morton (Moraine Products Co.), *Porous Metallic Bearings.* Powdered materials, such as Cu, Sn, Pb, graphite and salicylic acid are fed onto a conveyer, compressed into a sheet and sintered.

(4786) U. S. 1,937,465 (1933). C. F. Sherwood (Sherwood Patents Ltd.), *Sintered Material for Bearings & Bushings.* Powdered Cu, Sn, and Fe in a ratio of 85:10:5, are mixed, molded and sintered.

(4787) U. S. 1,958,740 (1934). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Porous Metal Bearings.* Porous metal bearings are produced by mixing Cu, Sn, graphite and boric acid, compressing and sintering the body to form a hard porous structure.

(4788) U. S. 1,959,775 (1934). W. C. Wilharm (Westinghouse Electric & Manufacturing Co.), *Self-Lubricating Materials.* A compressed low-friction composition comprises a major proportion of Cu and a minor proportion of Pb and Zn, and soaps of these metals distributed through the body.

(4789) U. S. 1,980,540 (1934). A. J. Langhammer (Chrysler Corp.), *Method of Making Trolley Shoes.* A method of manufacturing trolley shoes of bronze comprises separately pressing (coining) a pair of trolley shoe sections, each having a complimentary groove segment, from a mixture of powdered metals having different fusion points, sintering the pressed mixture at temperatures below the fusion point of one of the metals and above the fusion point of the other metals and impregnating the porous product with lubricant. The mixture preferred consists of 85% Cu, 13% Sn, 2% graphite and a small amount of stearic acid.

(4790) Brit. 449,521 (1936). Robert Bosch G.m.b.H., *Manufacture of Self Lubricating Bearings.* The hardening constituents are introduced as finely divided pre-alloys to the Cu-Sn powders, and the mixture is pressed and sintered at a temperature which lies below the melting point of the pre-alloys, which lose a part of their components, *e.g.* Sn, by diffusion.

(4791) Brit. 458,829; 458,832 (1936). E. Kramer, *Self Lubricating Bearings.* Bearings are made from metallic powders by pressing and sintering. For example, 100 kg. Cu powder, passing through a 20-50 mesh screen, is mixed with 10 kg. Sn powder and 1 kg. NH_4Cl and heated to 250° C. (480° F.) prior to further processing.

(4792) French 796,934 (1936). F. Sattler, *Production of Self-Lubricating Bodies.* Graphite powder as lubricant is mixed with metal powders, such as Cu-Sn, which are then formed, heated and pressed in successive steps in the same mold.

(4793) German 624,978 (1936). Schunk & Ebe, *Porous Bearing Metal.* A bearing metal consisting of 6-10% Sn or Pb, 6-12% Ni or Fe, 2-6% C, balance Cu, is annealed at a temperature between the sintering temperature and the melting point.

(4794) Swedish 85,507 (1936). E. Kramer, *Fabrication of Self-Lubricating Bearings.* A powder having a major fraction with a particle size of 10 mesh per $cm.^2$ (60 mesh per sq. in.) and a minor fraction of 60 mesh per $cm.^2$ (375 mesh per sq. in.) is pressed and sintered in such a manner that the porosity of the body is controlled.

(4795) Brit. 464,920 (1937). E. Kramer, *Composition Containing Metals.* A porous bearing body is formed by sintering metal (*e.g.* Cu, bronze) powder or chips and impregnating with NaOH, graphite, talc, etc.

(4796) French 819,616 (1937). Continental Oil Co., *Self-Lubricating Bearing Composition.* The material contains 68.4% Cu, 5.3% Sn, 5.3% Pb, 8% graphite, 7% oil, 2.5% diphenyl oxide plus 3.5% chlorodiphenyl oxide.

(4797) U. S. 2,075,444 (1937). R. P. Koehring (General Motors Co.), *Bearing Material and Seal Rings.* The material has a porous matrix of 75% bronze and 25% Pb and is produced from metal powders.

(4798) U. S. 2,084,756 (1937). G. F. Albrecht, *Spinning Ring.* The ring is pressed from metal powders, *e.g.*, 90/10 Cu/Sn plus graphite, utilizing the material of the ring itself as a capillary barrier between its outer and inner surface; a

lubricant is supplied to a groove on the outer surface, to insure a constant exudation of an oily film at the inner surface.

(4799) U. S. 2,097,671 (1937). R. P. Koehring (General Motors Corp.), *Porous Bearing Materials.* A mixture of Zn-stearate and powdered metals, such as 90% Cu and 10% Sn, is pressed and sintered.

(4800) Brit. 488,590 (1938). Continental Oil Co., *Self Lubricating Bearing Materials.* A metal powder mixture and a polar organic compound are pressed and sintered; the mixture contains Cu, Sn, Pb, P, S, Zn or a composition with halogenated compounds.

(4801) Brit. 492,618 (1938). General Motors Corp., *Method of Making Bearings.* The production process comprises press-fitting the porous metal bushing into the outer sleeve, and then heating both, to alloy the bushing and sleeve.

(4802) Canadian 373,492 (1938). E. Kramer, *Self-Lubricating Bearings.* Powdered Cu, Sb, Sn, and Pb are sintered to form a porous bearing which holds 40% of its own volume of lubricant.

(4803) German 661,071 (1938). E. Kramer, *Self-Lubricating Bearings.* Bearings are made by pressing and sintering a mixture of metal powders, *e.g.* Cu and Sn or Fe, of different particle sizes; finishing is carried out with sintered carbide or diamond tools.

(4804) U. S. 2,129,844 (1938). E. F. Kiefer (Union Carbide & Carbon Corp.), *Method of Making Bearing.* A bearing is made by molding and sintering a mixture of unalloyed finely divided CuO with an ammonium salt.

(4805) U. S. 2,132,867 (1938). J. H. Davis (General Motors Co.), *Metal Bearings.* Porous bronze bearings are made from powder by pressing, sintering and bonding the product to a hard sleeve.

(4806) U. S. 2,133,761 (1938). C. Tietig, *Porous Metal Products.* Finely divided metal powder containing 82-86% Cu, 8-9% Sn or Zn, 1-3% graphite and 3-10% CuO, is mixed, then pressed and sintered in H_2 to create voids in the product through removal of the oxide; the voids are then filled with oil.

(4807) Canadian 385,061 (1939). C. Tietig, *Porous Metal Object Manufacture. Cf.:* U. S. 2,133,761 (No. 4806).

(4808) French 842,796 (1939). C. Tietig, *Porous Metallic Articles. Cf.:* U. S. 2,133,761 (No. 4806).

(4809) Italian 368,499 (1939). Johnson Bronze Co., *Improvement in Bronze Bearings and in their Manufacture.* Pressed and sintered bearings consist of 25-90% bronze powder, 67.5-9% Cu and 17.5-1% Sn powder.

(4810) Italian 374,961 (1939). G. Ghiglione, *Manufacture of Bearings Including Combustion-Engine Bearings.* Bearings of a porous self-lubricating material are produced from metal powders, such as Cu and Sn.

(4811) U. S. 2,159,327 (1939). J. V. Hendrick (Chrysler Corp.), *Bearings.* A bearing consists of a porous metal journal member produced from Cu powder with 10% Sn and a solid lubricant, such as boric acid, a yieldable sleeve of rubber, and an intermediate sleeve or layer of an oil impervious material.

(4812) U. S. 2,177,853 (1939). C. H. Wills (Chrysler Corp.), *Composition of Matter and Method of Making Same.* A porous bearing structure consists of a compressed and sintered mass of powdered metal which has distributed throughout it 0.25-1% finely divided particles of vermiculite from which chemically combined moisture has been removed by heat treatment. Typical compositions are 25% Cu, 73.5% Fe, ½% vermiculite and 1% filler; or 88¼% Cu, 10% Sn, ¾% vermiculite and 1% filler.

(4813) U. S. 2,182,741 (1939). W. F. Bolesky, W. Waleke and J. A. Lutz, *Porous Metal Article and Method of Making Same.* A bearing material consists of 87% Cu, 10% Sn, 1% soy bean flour, 1% graphite, and 1% borax; the powders are mixed in a tumbler, briquetted, and heat treated.

(4814) Brit. 518,267 (1940). C. Tietig, *Porous Metallic Objects.* Metal powders are mixed with 2-20% of a reducible oxide, *e.g.* CuO or CdO, pressed, and sintered below 925° C. (1700° F.).

(4815) Brit. 521,177 (1940). Johnson Bronze Co., *Bronze Bearings.* Bronze bearings include particles of Cu-Sn alloy to which Cu has been bonded by sintering.

(4816) U. S. 2,187,086 (1940). R. P. Koehring (General Motors Corp.), *Metallic Element and Method of Making Same.* Sintered porous metal element composed of Cu-Ni, bronze, or Fe-alloy, of sponge-like physical structure has a lubricant held within its pores.

(4817) U. S. 2,198,702 (1940). R. P. Koehring (General Motors Corp.), *Method of Making Molded Porous Metal Articles such as Bearings.* A mold is filled with a metal powder including two metallic components of different melting points, *e.g.* Cu-Sn, and is passed through a hot sintering chamber containing a non-oxidizing atmosphere; the powders are sintered into a rigid porous alloy structure which will shrink and can readily be ejected from the mold after sintering.

(4818) U. S. 2,203,895 (1940). J. H. Davis, R. P. Koehring and J. T. Marvin (General Motors Corp.), *Method of Sintering Porous Metal Objects.* Powdered Cu-Sn briquettes including small quantities of carbonaceous material are heated in an oxidizing atmosphere to burn out a portion of the C and are then heated further in reducing atmosphere.

(4819) Brit. 540,865 (1941). The Glacier Metal Co., Ltd., W. K. Boyle and T. Bate, *Bearings.* The bearings have an anti-friction bearing surface of sintered cuprous material and a lubricant reservoir in contact with the surface.

(4820) German 712,702 (1941). A. Mantigassa, *Porous Bushes.* An alloy of 55-75% Cu, 15-40% Pb, and 5-10% Sn is pulverized to -30 +150 mesh and mixed with 5% very fine raw Cu powder and borax; the powder is then pressed at 2½ tons, and sintered.

(4821) Canadian 405,397 (1942). W. F. Bolesky, *Porous Metal Article Manufacture. Cf.:* U. S. 2,182,741 (No. 4813).

(4822) Brit. 554,110 (1943). General Motors Corp. and R. G. Olt, *Manufacturing of Porous Metal Articles.* Porous cylindrical bearings with or without a steel backing are made by feeding a metal powder slurry into a rotating cylinder, driving off the solvent, and then sintering by induction while being held in place by centrifugal force.

(4823) U. S. 2,310,061 (1943). O. R. Bowen (General Motors Corp.), *Porous Metal Articles.* Sn and Cu powder are mixed in suitable proportions to form a bronze, with 0.5-1.5% $CuCO_3$ acting as a die lubricant, shaped, then sintered in a suitable atmosphere to cause Cu and Sn to alloy together to form a bronze and to decompose the $CuCO_3$ into a gaseous component and pure Cu.

(4824) U. S. 2,322,733 (1943). J. A. Lignian (General Motors Corp.), *Porous Metal Bearings Suitable for Extreme Load Conditions.* A sintered porous Cu-base metal blank is impregnated with Babbitt.

(4825) U. S. 2,326,000 (1943). C. P. Teeple (Crane Packing Co.), *Bearing.* A molded self-lubricating bearing incorporates powdered Sb, Pb and/or Cu, and/or bronze with graphite and asbestos.

(4826) U. S. 2,337,588 (1943). W. G. Calkins (Chrysler Corp.), *Porous Metal Article.* A piston packing ring of a sheet-like porous bearing metal is formed of a layer of powdered Cu, Sn and graphite.

(4827) German 745,122 (1944). Allgemeine Elektrizitäts Gesellschaft and K. Marquardt, *Self-Lubricating Metal Bodies.* A mixture of metal powder (Cu) and graphite is cold-pressed, heated to the sintering temperature outside the press, and then re-shaped.

(4828) U. S. 2,376,722 (1945). A. J. Podell, *Sintered Porous Bronze for Bearing in Mixing Attachment.* A mixing attachment bearing utilizes sintered bronze soaked in oil as orificed antifriction blocks.

(4829) U. S. 2,390,050 (1945). M. G. Bales (General Motors Corp.), *Plate and Bearing Assembly.* An assembly comprises a plate shaped to provide an annular channel between a peripheral flange and a flange surrounding a central hole, a second plate, porous metal bearing buttons attached to one plate and bearing on the other plate, spring means, and a lubricant absorbing member for supplying lubricant to the bearings.

(4830) Brit. 580,039 (1946). Fisher Bearings Co. Ltd. and C. E. Marshall, *Cages for Roller Bearings.* A self lubricating cage is made from sintered metal powder, *e.g.*, Cu, Sn, Pb, Zn, Al or brass, by sealing the surface of the cage, except those of the edges of the pockets for the rollers, by electrodeposition or spraying with Zn.

(4831) U. S. 2,393,203 (1946). J. C. Tarbell and J. H. Conant, *Bearing.* A bearing construction comprises a lubricant-impregnated porous metal member formed by a mixture of 88.5% Cu, 10% Sn and 1.5% of a solid lubricant and a central shaft and support.

(4832) U. S. 2,403,255 (1946). G. F. Albrecht, *Spinning and Twisting Ring.* U. S. 2,084,756 (No. 4798) is improved by making the traveler-guiding portion of the ring of a porous body of Fe or Cu, highly compressed and sintered, so that the whole ring is one porous body.

(4833) U. S. 2,403,460 (1946). J. J. Rozner (Aetna Ball Bearing Mfg. Co.), *Ball Bearings.* Compressed powdered metal bushings (brass or bronze) and a porous powdered metal floating seal having lubrication characteristics are used in connection with ball bearings.

(4834) Brit. 585,875 (1947). General Motors Corp. and J. T. Marvin, *Manufacturing of Porous Metal Articles.* Improvement of Brit. 554,110 (No. 4822). A binder or volatile solvent is incorporated into the metal powder, *e.g.*, Cu, Sn, Fe or their alloys.

(4835) Brit. 596,626 (1948). The Glacier Metal Co. Ltd. and George Cohen Sons & Co. Ltd., *Material for Bearing Surfaces.* Journal bearings are made by including cemented carbide particles in the porous bronze matrix, and produced by presintering the carbides, crushing and mixing them in a ratio of 1:4 with powdered Pb bronze.

(4836) Brit. 606,541 (1948). W. F. Toynbee, *Lubrication of Die-Set Pillars.* The pillar is drilled axially and radially to provide a reservoir, the radial passages ending in a ring of porous bronze.

(4837) Brit. 608,251 (1948). P. & C. Garnett Ltd. and N. B. Barber, *Self-Lubricating Bushes for Journal Pins of Textile Rollers.* Each pin is run in two porous bronze bearings which are reinforced by being encased in a 20 gauge seamless drawn tube with an interposed length of press-fitting tubing.

(4838) Brit. 615,172 (1949). The Birmingham Small Arms Co. Ltd., S. C. Wilsdon and P. J. Ridout, *Powdered Metal Composition for Bushes.* The compositions are 74.625% Cu, 7% Sn, 17.5% Pb, 0.875% graphite; or, 71% Cu, 8% Sn, 20% Pb, 1% graphite. The admixture of graphite is claimed to prevent sweating out of Pb during sintering.

(4839) Brit. 616,185 (1949). Trico Products Corp., *Shaft Bearings.* Sintered porous graphited bronze bushings are press-fitted to the journals.

(4840) Brit. 622,779 (1949). The Morgan Crucible Co. Ltd. and T. Seymour, *Lapping Tools.* The lapping carrier consists of a bushing of sintered bronze or Fe, secured to the shank by a split core with a tapered internal bore.

(4841) U. S. 2,459,936 (1949). R. H. Hasler (The Hasler Stevens Corp.), *Rotary Valve for Internal-Combustion Engines.* The invention provides means for automatically applying proper pressure of the lubricating pads against the rotating valve disks; the pads may be made of sintered metal, C or any oil-impregnated porous bearing material, such as bronze.

(4842) U. S. 2,482,518 (1949). R. W. Schuck (Westinghouse Electric Corp.), *Sealed Sleeve Bearing.* A self-lubricating porous bronze bearing has an oil reservoir and is interchangeable with sealed anti-friction bearings.

ii. Iron-Base

(4843) French 725,241 (1932). The Manganese Bronze & Brass Co., Ltd., *Porous Metals for Bearings. Cf.:* Brit. 391,155 (No. 4844).

(4844) Brit. 391,155 (1933). The Manganese Bronze & Brass Co. Ltd. and C. F. Sherwood, *Porous Metal Articles.* Bearings are produced from spongy Fe and a volatile lubricant, such as stearic or another fatty acid, sintered by an electric current in a reducing atmosphere.

(4845) U. S. 1,974,173 (1934). W. G. Calkins (Chrysler Corp.), *Porous Sintered Bearing Material.* Sintered bearings are produced from powdered Fe, Cu, and graphite in a ratio of 88.5:10:1.5.

(4846) Brit. 423,582 (1935). The Manganese Bronze & Brass Co., *Method of Manufacturing Bearing Bushings.* Porous bearing bushings of 88.5% sponge Fe, 10% Cu, 1.5% graphite, and 1.5% lubricant are pressed and sintered.

(4847) U. S. 1,992,548 (1935). C. P. Short (General Motors Corp.), *Structure Made From Comminuted Material.* A bonded material suitable for porous oil retaining bearings comprises cast Fe powder and Zn, Sn and Cu.

(4848) U. S. 1,992,549 (1935). C. P. Short and R. P. Koehring (General Motors Corp.), *Alloys Suitable for Porous Bearings.* Fe powder is alloyed with Zn on the surface of particles only.

(4849) Brit. 464,727 (1937). Hevaloid A. G., *Improvement in or Relating to Porous Metallic Products.* A porous bearing or filter is made from powdered Fe-Cu, sintered in a high-frequency furnace, and oil-impregnated.

(4850) U. S. 2,074,185 (1937). A. J. Langhammer and W. G. Calkins (Chrysler Corp.), *Method for Heat Treating Porous Metal Structures.* Impregnated porous metal structures are produced by subjecting in a non-oxidizing atmosphere a compressed mass of finely comminuted Fe and a more fusible metal, *e.g.* Cu, to a temperature below the melting point of Fe but above that of the more fusible metal, then quenching before exposing to an oxidizing atmosphere; after annealing in a non-oxidizing atmosphere, the structure is quenched in a lubricant which impregnates the pores.

(4851) U. S. S. R. 50,695 (1937). A. A. Abinder and N. F. Pravdynk, *Porous Anti-Friction Alloys.* Fe-base alloys are produced by consolidating cast Fe shavings ground to powder.

(4852) Brit. 491,415 (1938). Robert Bosch G.m.b.H., *Compressed Metal Powders.* Oil-impregnated porous bearings consist principally of Fe with additions of Cu, Sn, Al or Mg, and graphite.

(4853) Brit. 495,824 (1938). H. Vogt, *Porous Metal Bodies for Bearing Bushings, Packing Rings.* A method of producing antifriction material in which spongy Fe particles of a porosity corresponding to a specific gravity of 1.0-1.5 are compressed, yields a self sustaining body with a specific gravity of 4.5-5.5.

(4854) French 822,858 (1938). Seri-Holding, S. A., *Porous Metal Bodies.* Porous metal bodies are composed of granules of metals, *e.g.* Fe, which form cavities with each other and which are welded together by the aid of a fused metal.

(4855) German 666,363 (1938). H. Vogt, *Porous Bearing.* A porous bearing, consisting of Fe powder of 0.05-1 mm. grain size is pressed and sintered without binding agents.

(4856) German 668,604 (1938). I. G. Farbenindustrie A. G. and W. Schubardt, *Self-Lubricating Bearings.* Self-lubricating bodies for friction bearings are composed of graphite and sintered metal powders, *e.g.* Fe, produced by thermal decomposition of metal carbonyls.

(4857) Swiss 199,261 (1938). H. Vogt, *Production of Porous Sintered Bearings.* Porous Fe particles of 0.05 mm. diameter, having up to 5% impurities, are pressed and sintered without the addition of other materials.

(4858) Austrian 158,392 (1940). H. Vogt, *Porous Bearings.* The bearings are produced from Fe sponge granules of 1 mm. size and with a bulk weight of 1.25.

(4859) U. S. 2,214,104 (1940). J. M. Hildabolt and A. R. Shaw (General Motors Corp.), *Porous Metal Articles for Use in Bearings or the Like.* A porous bearing consists of a porous matrix of sintered Fe with 2% graphite, coated with a soft metal insoluble in Fe, such as Pb, and impregnated with a lubricant mixed with Fe and Cd or Bi.

(4860) U. S. S. R. 56,987 (1940). A. A. Abinder and N. F. Pravdyuk, *Porous Bearing Alloy.* The alloy is obtained from a mixture of alloying material, ground cast Fe, and up to 10% graphite.

(4861) German 714,396 (1941). Demag A. G., *Sintered Iron Bearings.* The inclusion of 1-1.5% Sb in sintered Fe-Pb bearings improves the pressure limit to 12-15 tsi and the Brinell hardness to 40-50.

(4862) U. S. 2,229,330 (1941). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Porous Metal Product and Method of Making Same.* A porous sintered bearing contains 90% Fe, and 10% Cu.

(4863) U. S. 2,239,800 (1941). H. Vogt and E. Klotz, *Production of Sintered Articles.* A porous anti-friction metal, having a substantial oil-absorbing capacity and great mechanical strength, is produced by sintering Fe powder.

(4864) Belgian 445,400 (1942). Deutsche Gold- & Silberscheideanstalt, *Non-Rusting Bearing Bushings.* A mixture of Fe and PbO is reduced at elevated temperatures, then compressed, shaped in a press, and agglomerated at an elevated temperature in the presence of H_2.

(4865) U. S. 2,293,400 (1942). A. W. Morris and W. J. Sinnott (Isthmian Metals Inc.), *Method for Producing Metal Bodies.* Porous oil-impregnated bearings are made from powdered Fe by hot pressing under vacuum; the formed objects are expelled through a liquid seal so that the pores are impregnated with the sealing medium.

(4866) U. S. 2,299,192 (1942). H. Tormyn (General Motors Corp.), *Sintered Articles Such as Bearings and Bushings.* The porous products are made by pressing Fe metal powders under high pressure, sintering in a non-oxidizing atmosphere at 1095-1120° C. (2000-2050° F.), thereafter applying Cu powder to the surface of the sintered briquette and pressing to compact the Cu and densify the Fe briquette, and finally sintering at 1040° C. (1900° F.) in a non-oxidizing atmosphere.

(4867) U. S. 2,301,756 (1942). R. S. Shutt (Battelle Memorial Institute), *Powder Metal Bearing and Method of Making Same.* A porous bearing, containing up to 10% Se and having superior antifriction properties under service conditions is made of a sintered Fe-base alloy capable of producing a lubricant film.

(4868) French 883,407 (1943). Deutsche Gold- & Silberscheideanstalt, *Production of Bearings from Iron Powder.* The Fe powder is mixed with 1-15% of PbO, formed and sintered in the presence of H_2, whereby the PbO is reduced.

(4869) German 741,535 (1943). H. Vogt, *Hardening of Sintered Sliding Bearings.* Porous Fe bearings are hardened by subjecting them to attack by N or C from diffusing gases.

(4870) German 745,806 (1944). H. Vogt, *Bearings and Bushings.* The bearings are made from porous sintered metal, especially sponge Fe; the porous bodies are saturated with a metal salt solution and the metal is subsequently reduced within the pores of the sponge.

(4871) U. S. 2,365,552 (1944). F. L. Hill, *Mono-Ball Bearing.* Self-aligning steel bearings have bearing members molded from powdered Fe metal, sintered and repressed to size.

(4872) Brit. 577,198 (1946). Mallory Metallurgical Products Co., *Bearings.* Porous Fe, Ni, Co bearings impregnated with Hg, are claimed to be an ideal substitute for small oilless bearings since a liquid metal lubricant will be present even at ordinary temperatures.

(4873) U. S. 2,397,164 (1946). J. E. Shafer, *Bearing.* Powdered Fe is used in a self-aligning bearing assembly.

(4874) U. S. 2,397,626 (1946). W. C. Shriver (Borg-Warner Corp.), *Bushing.* Powdered Fe and Pb or graphite is used in making bushings.

(4875) Brit. 591,319 (1947). A. B. Pulverkemi, *Sliding Friction Bearings.* Shafts are run in oil-impregnated bushes of sintered Fe having a sliding fit.

(4876) French 939,632 (1948). N. V. Philips' Gloeilampenfabrieken, *Manufacture of Self-Lubricating Bearings.* The grooves of a tubular Fe part are filled with carbonyl Fe or Ni powder by centrifuging; sintering is accomplished by

high-frequency heating. The process is repeated at decreasing sintering temperatures to produce a greater porosity at the surface.

(4877) U. S. 2,452,323 (1948). G. E. Platzer (Chrysler Corp.), *Spinning Ring.* A ring whose annular main body is adapted to be engaged by a revolving traveler is formed from sintered metal powders, *e.g.* Fe and/or Sn, Cu, and has capillaries in the flange portion that are filled with a lubricant.

(4878) Austrian 162,862 (1949). Gebr. Böhler & Co., A. G., *Production of Bearings.* The bearings are produced from powders of Fe, Fe_2O_3 and P compounds, formed by phosphating in superheated steam.

iii. Others (Aluminum-Base, Babbitt, Lead-Base)

(4879) U. S. 269,636 (1882). F. E. Canda, *Bearings.* Bearings are manufactured by subjecting to pressure a mold containing Hg and powdered metals.

(4880) U. S. 590,369 (1897). J. W. Haley, *Lubricating Material.* Self-lubricating bearings are made from a compound of glass, Pb, plumbago and Sb tempered with brass and Al.

(4881) U. S. 981,767 (1911). J. L. Jones (Westinghouse Electric & Mfg. Co.), *Babbitt Metal.* Bearing metal is made from a large percentage of chippings and turnings of Babbitt metal.

(4882) German 259,092 (1913). H. I. Hannover, *Production of Porous Bearings.* The pores of a metal with a low melting point, *e.g.* Pb, are filled chemically or galvanically with a metal of high melting point, *e.g.* Ni, whereupon the lower melting metal is melted out by heating the body.

(4883) U. S. 1,198,152 (1916). R. E. Rich, *Bearing Material.* Self-lubricating bearing material consists of graphite particles heavily coated with Pb to produce a specific gravity of 6.8 distributed throughout a mass of molten Babbitt metal.

(4884) U. S. 1,390,197 (1921). G. G. Dower (G. I. Alden), *Self-Lubricating Bearing.* An oilless bearing is made from bearing metal plus 5-50% commercially pure graphite; the metal is melted under pressure and cooled quickly, so that the graphite particles are surrounded by the metal.

(4885) U. S. 2,107,223 (1938). C. E. Swartz (Cleveland Graphite Bronze Co.), *Bearing Metal Alloy.* The alloy contains 1-20% Sb, 1-20% Sn, 0.1-3% Cu, 0.01-5% Te, and balance Pb.

(4886) Brit. 505,159 (1939). Karl Schmidt G.m.b.H., *Bearing Metals. Cf.:* German 742,850 (No. 4887).

(4887) German 742,850 (1943). Karl Schmidt G.m.b.H. and R. Sterner-Rainer, *Aluminum-Base Bearing Metal.* A mixture of graphite, and turnings of Al or an Al alloy is prepressed, heated to its deformation temperature (approximately 600° C., 1100° F.) and pressure-molded.

(4888) U. S. 2,386,544 (1945). H. L. Crowley, *Method of Producing Metallic Bodies.* Light weight, porous metallic bodies are made by preparing a mixture of metal, *e.g.* Fe, Al, Mg, Cu, W or their alloys, a resin and stearic acid in proportions of 10, 2, and 0.4 respectively, and then molding and sintering.

(4889) U. S. 2,418,881 (1947). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Sintered Porous Aluminum-base Bearings.* Bearings are made by incorporating Tl or Tl-alloys into Al powder; the Tl may be added by impregnating the compacted Al-base, or by adding it to Al-powder before molding.

(4890) U. S. 2,447,980 (1948). F. R. Hensel (P. R. Mallory & Co. Inc.), *Making Porous Bearing Surfaces.* An alloy of a metal, such as Al, Ag, Pt, etc. with Zn or Cd is rolled to a thin sheet and heated to evaporate the lower boiling metal; the porous product is impregnated with oil or Pb.

B. Filters

(4891) Austrian 113,314 (1929). F. Sigmund, *Porous Metal Bodies for Filters.* The porous metal is produced by sintering powdered metals with a melting point below 500° C. (930° F.).

(4892) German 562,158 (1932). Vormbusch & Co. G.m.b.H., *Production of Bodies for Filter.* Filter bodies are produced by mixing Fe powder with Si or Cr powder, forming, drying, and annealing the bodies.

(4893) U. S. 1,893,330 (1933). C. L. Jones, *Permeable Metal for Heating and Filtering Liquids.* Metallic particles are oriented by subjecting them to the action of a magnetic field, and then bonded together.

(4894) Brit. 452,764 (1936). A. H. Stevens, *Porous Metal Body.* A gas diffusion diaphragm of finely divided Ni is produced from a Ni-Hg amalgam by evaporating Hg.

(4895) U. S. S. R. 48,191 (1936). V. M. Muchatschev, *Sintering of Metal Powders.* Filters are produced by sintering the powders in air-sealed furnaces.

(4896) Brit. 497,585 (1938). General Motors Corp., *Improvement in Filter Elements.* An uncompacted Cu-Ni mixture is sintered to form a thin, porous sheet.

(4897) U. S. 2,122,053 (1938). H. Burkhardt (Accumulatoren Fabrik A. G.), *Porous Metallic Bodies Such as Filters.* Powdered metal is mixed with oil or fat, and a metal-hydroxide, and sintered in a reducing atmosphere.

(4898) U. S. 2,157,596 (1939). J. H. Davis (General Motors Corp.), *Thin Sheets of Highly Porous Metal Such as Porous Bronze Used for Filters.* A powdered mixture of Ni and Cu is spread loosely upon a hard smooth surface of a graphite mold, then heated in a reducing atmosphere to 1100° C. (2010° F.) for 8 minutes; after cooling, the porous sheet is lifted from the graphite surface.

(4899) U. S. 2,220,641 (1940). J. H. Davis (General Motors Corp.), *Porous Filter.* Porous metallic sheets are produced by sintering together a thin layer of mixed uncompacted Cu and Ni powders.

(4900) Belgian 438,356 (1941). S. A. Lavorazione Leghe Porose, *Porous Metal Mass For Air Filters.* Fragments of Fe wire of 1.1-1.4 mm. diameter are mixed with 5% of powdered Cu and 5% of a 25-30° Baumé solution of Na silicate; the process involves compressing the mixture at 200 kg./cm.^{2} (2800 psi) and gradually heating to 880° C. (1620° F.).

(4901) U. S. 2,267,918 (1941). J. M. Hildabolt (General Motors Corp.), *Porous Article and Method of Making Same.* A filter element comprises a homogeneous sheet of powdered metal consisting of two strata having different degrees of porosity.

(4902) Brit. 544,833 (1942). R. G. Olt (General Motors Corp.), *Porous Metal Bodies Containing Tin and Copper. Cf.:* U. S. 2,273,589 (No. 4904).

(4903) Brit. 544,969 (1942). General Motors Corp., R. P. Koehring, J. M. Hildabolt, and J. T. Marvin, *Porous Metal Filter.* The filter possesses varying porosity due to the utilization of different grain sizes of the same metal powder.

(4904) U. S. 2,273,589 (1942). R. G. Olt (General Motors Corp.), *Porous Metal Bodies Containing Tin and Copper.* A sintered uncompacted mixture of Cu-Sn powders with highly controlled shrinkage is used for filters and the like.

(4905) Swiss 216,467 (1942). S. A. Lavorazione Leghe Porose, *Porous Metal. Cf.:* Belgian 438,356 (No. 4900).

(4906) U. S. 2,297,817 (1942). C. W. Truxell, R. P. Koehring and J. M. Hildabolt (General Motors Co.), *Filter Element.* Non-compacted metal powders and an apertured plate of a more dense metal are bonded together by sintering.

(4907) U. S. 2,300,048 (1942). R. P. Koehring (General Motors Corp.), *Porous Sheet Material Such as Porous Filters.* A porous bronze sheet with continual porosity is produced by agitating the metal powder of varying grain size in gasoline in a large chamber, causing the powder to settle upon a supporting surface by gravity, according to grain size, and sintering the settled powder under suitable conditions.

(4908) U. S. 2,327,805 (1943). R. P. Koehring (General Motors Corp.), *Articles from Porous Iron Such as Filters for Acidic Crude Oils.* The filters are made by coating Fe particles with Pb or PbO, molding, and sintering above the melting point of Pb, but below the melting point of Fe.

(4909) U. S. 2,338,941 (1944). R. D. Howard (Petroleum Research Corp.), *Refining Petroleum.* A permeable filter mass of Zn in the oxidized condition is used to remove residual heavy reaction products from petroleum distillated.

(4910) U. S. 2,359,386 (1944). E. W. Reinsch (General Motors Co.), *Fluid Separator.* The separator has a porous metal membrane made from sintered uncompacted metal powders.

(4911) U. S. 2,378,476 (1945). G. E. Guellich (American Optical Co.), *Porous Filter in Coating Apparatus.* A porous heated metallic filter serves to accelerate the vaporized metal particles passing through it.

(4912) Brit. 580,414 (1946). Callite Tungsten Corp., *Porous Metal Body for Filters. Cf.:* U. S. 2,464,517 (No. 4931).

(4913) Brit. 581,700 (1946). General Motors Corp., *Porous Metal Articles.* Compacts with a high length to diameter ratio as used in filter bodies are given uniform porosity by pressing the powder in a die with a cross section varying inversely with the density of the pressing. Sintering is performed in the usual way, and is followed by correcting for uniform density by suitable drawing.

(4914) Canadian 435,837 (1946). Callite Tungsten Corp., *Porous Metal Body for Filters. Cf.:* U. S. 2,464,517 (No. 4931).

(4915) U. S. 2,398,719 (1946). O. Rasmussen (General Motors Corp.), *Method of Making Porous Metal Articles.* Porous metal articles, such as filters, of elongated shape and substantially uniform density throughout are produced by briquetting, sintering and sizing; the density is substantially constant throughout the length which is three times that of diameter.

(4916) U. S. 2,401,797 (1946). O. Rasmussen (General Motors Corp.), *Filter.* A powdered mixture of 90% Cu and 10% Sn forms a porous block for cooling and purifying oil in internal combustion engines.

(4917) U. S. 2,404,872 (1946). J. M. Walker (Selas Corp.), *Method for Separating Immiscible Fluids.* A porous body of metal, ceramics, etc. is impregnated with material which is preferentially wetted by one of the liquids to be separated.

(4918) Brit. 593,562 (1947). Sintered Products Ltd. and J. W. Lennox, *Manufacture of Porous Metal Articles.* A mixture of bronze and Ni powder is preferred to mixed Cu, Sn, and Ni powders for the manufacture of porous filters.

(4919) U. S. 2,424,211 (1947). E. F. Webb (Chrysler Corp.), *Gasoline Filter for Internal Combustion Engines.* The filter, produced from sintered metal powder, is composed of a pair of porous disks, having facing internal concaved sides, and having an enforcing member of a perforated disk between them.

(4920) U. S. 2,430,078 (1947). E. W. Reinsch, D. W. DeBra and T. W. Kunzog (General Motors Corp.), *Porous Metal Filter.* Porous metal bodies are used for hollow metallic filter elements adapted to be placed over a perforated tube so that the filtered fluid passes into the tube.

(4921) Brit. 601,921 (1948). J. W. Lennox, *Filters.* Sintered metal filters are used for liquids in conjunction with a filter aid.

(4922) Brit. 604,063 (1948). Sintered Products Ltd. and C. E. Sinclair, *Distributing Gases in Liquids.* Liquids can be aerated by means of perforated tubes surrounded with porous metal.

(4923) French 934,474 (1948). Lignes Télégraphiques et Téléphoniques, *Filters for Gases and Liquids.* The filters are produced by hot-pressing the metal powder in form of a cartridge.

(4924) U. S. 2,447,048 (1948). H. J. Baker (Union Carbide & Carbon Corp.), *Backfire Arresting Filter.* The filter comprises a disk of porous, heat conductive, sintered metal, having small interconnected pores, and a non-porous metallic button, embedded in and supported by the porous disk, and extending over the central portion of the downstream face of the disk, to receive the impact of the flame.

(4925) U. S. 2,447,086 (1948). M. L. Olson and E. A. Berger (Union Carbide & Carbon Corp.), *Backfire Arresting Filter.* The filter is composed of a porous metal disk having interconnected pores, a casing enclosing the disk, and a non-porous metal member in the middle of the disk, to receive the impact of the backfire.

(4926) U. S. 2,450,339 (1948). F. R. Hensel (P. R. Mallory & Co., Inc.), *Making Porous Filters.* Micro-porous filters are made according to U. S. 2,447,980 (No. 4890) by alloying precious metal with Zn, rolling the alloy, and volatilizing the Zn.

(4927) U. S. 2,454,982 (1948). D. Wallace (General Motors Corp.), *Filter Element.* The filter consists of a strong metal backing plate, bonded with a layer of sintered non-compacted metal powder, one particle thick throughout the contact area, each particle contacting the adjacent particle.

(4928) Brit. 616,839 (1949). Sintered Products Ltd. and J. W. Lennox, *Manufacture of Porous Metal.* Carbonyl Ni is mixed with 10% methyl methacrylate, compacted and sintered in H_2; the compact has a porosity of 58% and is suitable for filters, etc.

(4929) U. S. 2,462,045 (1949). J. Wulff, *Method of Producing Filters.* Corrosion-resistant filters are made by mixing stainless steel powder with Cu powder and shaping the mixture by pressing in a die. The resulting compact is sintered in a reducing atmosphere to bond the stainless steel particles, and then subjected to a treatment which dissolves the Cu, such as with the aid of a pickling solution.

(4930) U. S. 2,463,825 (1949). F. W. Strassheim, *Filter Element.* A filter, made either of powdered bronze or of porous rubber, is produced in one piece and is generally circular in shape; it has a series of concentric corrugations, bridges extending between and connecting the corrugations and being integral with the body.

(4931) U. S. 2,464,517 (1949). J. Kurtz (Callite Tungsten Corp.), *Method of Making Porous Metallic Bodies.* Porous refractory metal bodies, especially suitable for filters, are produced by coating a W powder consisting of broken W crystals with $AgNO_3$, mixing the coated powder with paraffin, pressing the mixture to a desired shape and heating at increasing temperatures to volatilize the paraffin without leaving any residue. The $AgNO_3$ is reduced to a metallic Ag coating, and the mixture is then sintered to a strong, coherent, porous body.

C. Wear Resistance Products

(4932) German 315,234 (1919). G. Ising and H. Borofski, *Production of Metal Bodies.* Metal, *e.g.* Al, is made pasty, mixed with graphite powder, deoxidized, and pressed so highly, that the pressure and the heat, produced during the pressing, generate a welding of the metal particles together and around the graphite particles. The product is used for driving bands.

(4933) Swiss 80,422 (1919). G. Ising and H. Borofski, *Producing of Metal Bodies.* Al or bronze powder is mixed with graphite, deoxidized and pressed to shape. The method is suitable for production of porous materials of low coefficient of friction, *e.g.* bearings or driving bands for projectiles; by the addition of hard ingredients, materials suitable for grinding tools and friction elements are also possible.

(4934) Brit. 396,195 (1933). Chrysler Corp., *Metallic Compositions.* Porous wear resistant flexible elements for insertion between spring leaves are made of Cu, Fe, graphite and a volatile lubricant, and are sintered.

(4935) U. S. 2,042,635 (1936). E. L. Schellens (Shellwood-Johnson Co.), *Porous Metal Bodies Such as Those for Cutting of Abrasive Wheels.* An Fe-group powder and a low melting point metal, such as Cu, are heated with a non-metallic wet binder, and sintered in a reducing atmosphere.

(4936) U. S. 2,191,936 (1940). F. V. Lenel (General Motors Corp.), *Manufacture of Porous Iron Articles.* Sponge Fe with 3% C is briquetted at 30,000-45,000 psi and sintered in a non-oxidizing atmosphere at 960° C. (1750° F.); the briquettes increase in size. The material displays wear resistance.

(4937) U. S. 2,226,520 (1940). F. V. Lenel (General Motors Corp.), *Iron Article and Method of Making Same.* A sintered agglomerated powder of C-free Fe is bonded by an Fe-P eutectic and results in a porous, wear resistant material.

(4938) U. S. 2,291,734 (1942). F. V. Lenel, (General Motors Corp.), *Porous Metal.* Highly porous, wear resistant articles are made from a mixture of at least two metals, such as Fe and Ni, which are soluble in one another and form phosphides. The method of manufacture comprises adding P to the mixture to form a low-melting constituent between the metals and their phosphides, heating to a temperature exceeding the melting point of P, but below the melting point of the elemental metals, to cause the powder particles to be bonded into a highly porous article by the low-melting constituent.

(4939) U. S. 2,300,118 (1942). F. R. Hensel, E. I. Larsen and O. L. Fluharty (P. R. Mallory & Co. Inc.), *Lapping Carrier.* A material used for the production of extremely smooth and accurate surfaces is prepared by pressing and sintering metal powders. The lapping carrier has a grinding surface charged with abrasive, and consists of a porous body of sintered metal powder and pores partly extending through the grinding surface.

(4940) U. S. 2,360,473 (1944). W. G. Calkins (Chrysler Corp.), *Projectile Band.* The band has a porous metal bearing surface consisting of pressed and sintered metal powders.

(4941) U. S. 2,362,353 (1944). P. E. Cate (The Fulton Sylphon Co.), *Elements of Compressed and Sintered Powders.* A bearing or wearing ring of Cu and C is used as an attachment to a bellows.

(4942) U. S. 2,440,947 (1948). E. Hart (A. O. Smith Corp.), *Impeller for Centrifugal Pump with Wear Rings.* One of the wear rings of each pair of impellers is constructed of C or metal-bearing C, which will not gall or seize when brought into contact with the opposite wear ring of metal.

(4943) Brit. 618,293 (1949). Isthmian Metals, Inc., *Products of Powdered Iron or Iron Alloys.* Sintered steel shell-driving bands are made from electrolytic Fe powder, which is carburized and pressed to a density of 6.3, sintered, coined to density of 7.4, and finally sintered.

(4944) U. S. 2,491,238 (1949). L. F. Whitney (Isthmian Metals, Inc.), *Heat-Treating Iron Steel Body.* A driving band is attached to a shell either during fabrication of the band or thereafter, and the banded shell is heat-treated simultaneously to soften the Fe band and leave the shell in a hardened condition. The starting material for the band is a loose and freely flowing Fe powder.

D. Miscellaneous Products (other than electrical)

(4945) Danish 37,071 (1927). K. Hansen, *Method for the Production of Porous Metals or Metal Alloys.* Porous metals are produced by a process in which the physical properties with respect to pore size, pore density, and pore shape can be predicted with accuracy.

(4946) Brit. 282,112 (1928). I. G. Farbenindustrie A. G., *Manufacture of Finely Porous Metal.* 60 parts of brass are heated with 160 parts of caustic soda, during which operation H_2 is evolved with formation of zincate, which is extracted by dilute HCl; as a result, porous Cu is left in an active condition.

(4947) Austrian 113,314 (1929). F. Sigmund, *Production of Porous Metal Bodies.* Metal powders are pressed to form a porous body which is heated in inert or reducing gas, with exclusion of O_2, and with or without pressure, until the particles are sintered, without becoming fluid. The porous bodies may serve as bearings, filters, catalysts, or as a matrix for friction elements.

(4948) U. S. 1,714,564 (1929). W. Koehler, *Anti-friction and Anti-abrasive Metal.* Particles characterized by a great cohesiveness due to their dendritic shape and self-matting properties, are molded into a porous body.

(4949) Brit. 330,018 (1930). I. G. Farbenindustrie A. G., *Porous Molds for Casting Metals.* Molds for casting metals consist of porous metals from powdered carbonyls, which are pressed and heated, in which the porosity of the metal in one part of the mold is greater than that in other places.

(4950) Brit. 339,645 (1930). I. G. Farbenindustrie A. G., *Porous Masses of Metal or Metal Oxides. Cf.:* German 558,751 (No. 4952).

(4951) French 700,740 (1931). I. G. Farbenindustrie A. G., *Metals and Alloys.* Porous alloys from powdered materials containing impurities capable of being eliminated by volatilization, are first heated to volatilize the impurities, then pressed and sintered.

(4952) German 558,751 (1932). I. G. Farbenindustrie A. G., *Porous Metals or Metal Oxides.* Mixtures of metals and a foam-forming material are mixed to produce a foam; the mixture is then dried and sintered to produce porous bearings, storage battery plates, filters, diaphragms, molds, and the like.

(4953) German 564,254 (1932). I. G. Farbenindustrie A. G., *Porous Metal Bodies.* The bodies are produced from powders made by the decomposition of metal carbonyls.

(4954) U. S. 1,918,893 (1933). H. Beckmann, *Porous Body.* A porous body comprises finely divided metals or brasses dispersed in a porous matrix.

(4955) U. S. 1,919,730 (1933). J. Koenig and F. Stoewener (I. G. Farbenindustrie A. G.), *Porous Metal and Metal Oxide.* Metals, metal oxides or such metal compounds as are converted into oxides on heating, are mixed with a liquid and a foam producing agent; a foam is produced, which is dried and sintered.

(4956) German 598,558 (1934). I. G. Farbenindustrie A. G., *Manufacture of Wicks.* Porous bodies are produced by sintering metal powders or metal carbides.

(4957) Austrian 144,453 (1936). E. Schattaneck and L. Haschek, *Wick for Liquid Fuels.* A wick made from porous metal is used for benzine, gasoline etc.

(4958) French 801,060 (1936). Accumulatoren-Fabrik A. G., *Porous Metals.* Oxides of metals and viscous products are molded and heated with a reducing agent to form a porous body.

(4959) U. S. 2,082,126 (1937). R. Schulz, *Production of Porous Metal Bodies.* Large-size particles whose volume is reduced during sintering are mixed with smaller-size particles of the same kind and then sintered in absence of O_2.

(4960) Brit. 494,956 (1938). W. D. Jones, *Porous Metal Articles.* Noble metal powders are subjected to a heat treatment to cause the particles to sinter together, after which the surface of the article is subjected to mechanical or thermal treatment to remove porosity.

(4961) Italian 373,764 (1939). L. Ghiglione, *Porous Metallic Material and its Manufacturing Process.* The material consists of a mass of wire pieces, ferrous or non-ferrous, coated with an extremely thin layer of Cu or some other metal having a melting point lower than the one of the underlying metal, irregularly matted down and subjected to compression and heating.

(4962) Italian 380,939 (1940). A. Mantigassa, *Porous Metal and its Process of Manufacture.* Metal wire is reduced to small pieces and immersed in a bath of Na silicate; after being taken from the bath, it is mixed with Cu powder containing powdered graphite and borax. The resulting metallic mass, after having been conglomerated into the desired shape, is then heat treated and sintered.

(4963) U. S. 2,198,042 (1940). L. Schlecht and K. Ackermann (I. G. Farbenindustrie A. G.), *Porous Metal Bodies.* Fe-group powders are made into porous bodies by sintering above 650° C. (1200° F.).

(4964) U. S. 2,215,532 (1940). E. A. Richardson, *Method and Apparatus Relating to Insulated Vessels.* A method of increasing the heat insulating qualities of porous walls of the vessel consists of causing to flow a cooling fluid to the cold side of the wall under such a pressure that a flow is maintained through the walls.

(4965) U. S. 2,215,723 (1940). W. D. Jones, *Process for Manufacturing Metal Articles.* Porous precious metal articles of a density lower than that of the metal in the cast condition are produced by pressing the powder at a low pressure and sintering; pores are not visible to the naked eye on the surface of the article.

(4966) U. S. 2,219,423 (1940). L. L. Kurtz (General Motors Corp.), *Method of Forming Porous Metal Articles.* A method of forming a thin sectioned porous metal articles comprises briquetting metal powders to a thin sheet of a simple shape and then sintering and causing the article to change its configuration to a more complex shape with a uniform density.

(4967) French 864,945 (1941). C. Chiecchio, *Production of Porous Bodies.* Interlaced Fe wires are sintered with fine Cu powder and Na-silicate.

(4968) U. S. 2,267,372 (1941). W. G. Calkins, R. E. Blue and W. W. Marvin (Chrysler Corp.), *Powdered Metal Product.* A metallic screen material is made from a mixture of 90% Cu, 10% Sn and a dry lubricant, which is heaped on the shaped surface of a block, then pressed and sintered.

(4969) U. S. 2,311,350 (1943). E. A. Richardson, *Apparatus for Controlling Combustion.* Air, as one reactant, is passed by pressure through a porous wall, at right angles to the thin fuel gas stream, so that it does not interfere with the flow of the fuel gas.

(4970) U. S. 2,323,146 (1943). D. H. Manney (General Motors Corp.), *Breather Plug for Electric Motors.* The plug is made from sintered uncompacted metal powders to form a porous wall through which the atmosphere is drawn into or ejected out of the motor housing.

(4971) German 750,118; 750,465; 750,466; 750,467 (1944). W. Guenther, *Porous Stator and Rotor for Colloid Mill.* The dispersing or emulsifying effect of a colloid mill is produced by forming the stator and the rotor of sintered metal with different porosities, which also act as classifiers. Details of the construction are given.

(4972) U. S. 2,341,739 (1944). R. G. Olt (General Motors Corp.), *Making Porous Bodies.* Metal powder is supplied to a rotating receptacle, to cause the powder to remain in contact with the wall; the powder is then scraped off in a uniform layer to form a cylindrical body, which is sintered.

(4973) U. S. 2,350,179 (1944). J. T. Marvin (General Motors Corp.), *Apparatus and Method for Making Composite Metal Parts.* Powdered metal is briquetted to form a flat coherent porous element; simultaneously a non-porous equally flat element having a higher melting point is heated under reducing conditions. The porous element is then superimposed on the non-porous one and both are bonded together.

(4974) U. S. 2,352,784 (1944). H. D. Geyer (General Motors Co.), *Fluid Seal.* A fluid seal used for sealing water pumps has a washer made from C and a self-lubricating metal, such as porous bronze.

(4975) U. S. 2,361,854 (1944). A. A. McCormack (General Motors Co.), *Refrigerating Apparatus.* A water jacket is secured by a porous sintered metal sheet to increase the condensing surface.

(4976) U. S. 2,372,581 (1945). W. D. Jones (Sheepbridge Stokes Centrifugal Castings Co.), *Preventing Formation of Ice.* The prevention of formation of ice on aircraft utilizes a mass of porous metal having antifreezing liquid applied to it by impregnation and penetration under pressure.

(4977) U. S. 2,377,632 (1945). J. D. Keller (Wean Engineering Co. Inc.), *Apparatus for Coating Sheets.* Porous rolls for use in an apparatus for coating sheets are produced by sintering Fe powders.

(4978) U. S. 2,382,601 (1945). A. L. Boegehold and R. H. Terry (General Motors Corp.), *Method of Making Sintered Powdered Iron Articles.* Powdered ferrous mill scale passing through a 250 mesh screen is mixed with powdered white cast Fe or steel, heated in a gas atmosphere to reduce the mixture and briquetted and sintered into a porous article.

(4979) U. S. 2,390,093 (1945). M. E. Garrison, *Airplane Wing De-icing Means.* The rigid outer wall at the leading edge of the device is composed of a sheet of smooth porous metal, a second wall of impervious metal, forming an enclosure between the two walls, through which a gas mixed with de-icing fluid is forced.

(4980) U. S. 2,391,577 (1945). S. E. Larson (George D. Roper Corp.), *Seal Ring.* Fe powder and graphite are briquetted to form a porous seal ring for a shaft.

(4981) U. S. 2,394,993 (1946). H. A. Gardner, *Porous Compositions.* A porous rigid dielectric metalloidal body is characterized by a honey-comb structure containing about 10% by weight of finely divided particles of Al or Mg bonded together by an acidic resinous binder.

(4982) U. S. 2,397,831 (1946). H. T. Bellamy, *Permanent Molds.* A product of controlled porosity is produced by mixing metal particles with a hydrated metal hydroxide, forming a colloidal suspension forming into shape, and heating in a reducing atmosphere to reduce the metal hydroxide.

(4983) U. S. 2,398,364 (1946). N. G. Elfstroem, *Method of Forming Cylindric Bushings.* A method of forming and shaping a sintered hollow cylindrical bushing to conform to the shape of a shaft on which the bushing is carried, involves giving the shaft a higher temperature to produce a larger volume of the shaft due to thermal expansion.

(4984) U. S. 2,409,295 (1946). J. T. Marvin and R. P. Koehring (General Motors Corp.), *Porous Metal Article.* The entire surface of a porous metal article, *e.g.* of Fe, is coated with a metal lower in the electrochemical series than the metal of the article, *e.g.* Cu, so that the coating is metallurgically bonded to the surface of the article, while the porosity is not impaired.

(4985) Brit. 587,453 (1947). H. A. Gardner, *Porous Compositions.* A honeycombed material is produced by sintering in H_2 a mixture of Al powder with solutions of synthetic or natural resins.

(4986) Brit. 593,959 (1947). H. T. Bellamy, *Molded Metallic Articles.* Permanent foundry molds of controlled porosity are made from a mixture of metallic saw filings and a $Fe(OH)_3$ paste.

(4987) U. S. 2,417,670 (1947). C. C. Anthes (Union Carbide & Carbon Corp.), *Porous Disk Type Gas Mixer.* A self-supporting porous flash arresting element, located in a blow pipe close to the nozzle, is formed by sintering bronze particles.

(4988) U. S. 2,430,841 (1947). E. J. Wulfhorst, *Fuel Absorber and Revaporizer.* An absorber, suspended in the carburetor outlet tube, consists of compressed, porous powder to permit the passage of air, and has a vast area for the distribution of particles of raw fuel.

(4989) U. S. 2,433,214 (1947). J. Halbert and R. R. Rawson (Sheepbridge Stokes Centrifugal Castings Co.), *Prevention of Ice Formation on Aircrafts.* The leading edges of an airfoil have a series of chambers with walls of rigid porous metal whose porosity is such that in the absence of flow resisting tubes the fluid would not reach all chambers.

(4990) U. S. 2,434,775 (1948). B. Sosnick, *Making Foam-Like Mass of Metals.* 90% Al and 10% Hg is melted in a closed chamber, so that no Hg vapor can escape; the molten mass is drawn from the high pressure chamber to volatilize the Hg, causing the Al to become foam- or sponge-like.

(4991) U. S. 2,444,620 (1948). A. L. W. Williams and D. R. Christians (Brush Development Co.), *Damping Means for Mechanical Vibratory Devices.* The damping material consists of sintered metallic spherical particles and forms a self-supporting body, which is utilized as an element of the housing for a diaphragm-crystal assembly; the material is sound-permeable but is rigid to withstand rough treatment.

(4992) U. S. 2,448,315 (1948). T. W. Kunzog (General Motors Corp.), *Combination of Restrictor and Heat Exchanger.* The device includes two concentric tubes, the inner filled with sintered, non-compacted metal powder, principally Cu; the inner tube is held in space through a highly porous metal filling in the outer tube.

(4993) U. S. 2,457,051 (1948). C. C. S. Le Clair (Tecalemit Ltd.), *Making Reinforced Porous Members.* The parts are made by suspending metal particles in a stream of liquid which passes through the interstices of a support, to distribute a portion of the particles into the interstices, so that they become firmly wedged and can be sintered.

(4994) Brit. 618,905 (1949). Power Jets Research and Development Ltd. and H. Constant, *Heat Exchangers.* A tubular recuperator is built up from a bank of standard hypodermic injection tubes which are positioned in end-plates of porous

masses of compacted metal powder, the assembly being then strengthened by sintering.

(4995) Brit. 620,944 (1949). Sintered Products Ltd., J. W. Lennox and C. E. Sinclair, *Blowpipe Burners.* A trap to prevent blow-back in welding torches is provided by inserting in the gas line a pair of disks of porous sintered metal.

(4996) Brit. 623,211 (1949). American Electro Metal Corp., *Means for Testing Furnace Atmospheres.* Porous Fe-graphite compacts are used to establish temperature-time curves for heat treatment or sintering of Fe parts, and for checking the composition of the atmosphere during operation.

(4997) U. S. 2,460,655 (1949). E. W. Rickmeyer (Jefferson Electric Co.), *Apparatus for Determining the Permeability of Materials.* The apparatus is used for timing the passage of a gas through the time delay elements of an Hg switch and for testing porous filter plugs and bearings of sintered metal. The time delay element is made of Ni particles that are compressed together in a mold so as to hold the particles together.

(4998) U. S. 2,472,170 (1949). W. W. Nash (The Dumore Co.), *Means for Supplying Lubrication as a Fine Mist.* The fine mist is produced in a reservoir that has a plug at one end made of porous metal, preferably sintered Fe or powdered Fe which has a porosity of 25% by volume.

8. FRICTION PRODUCTS (Clutch-Facings, Brake Linings)

(4999) Austrian 86,423 (1921). G. Ising and H. Borofski, *Method of Producing Bodies for Brake Linings.* The metal is heated until it is pasty and then mixed with metal or graphite powder and pressed so that the friction-producing metal particles are embedded uniformly in the matrix.

(5000) U. S. 1,722,890 (1929). A. Bluhm (S. A. Française Du Ferodo), *Friction Material.* A brake lining is made of powdered Pb incorporated in a textile fabric.

(5001) U. S. 1,757,408 (1930). A. L. Boegehold and C. R. Short (General Motors Corp.), *Friction Material.* A brake lining is made by coating fibers with powdered metal and sintering after the weaving operation.

(5002) U. S. 2,072,070 (1937). J. S. Fisher (General Metals Powder Co.), *Manufacture of Friction Articles.* A pressed and heat treated friction article consists of Cu and 3-20 parts inorganic non-metallic lubricant.

(5003) Brit. 496,763 (1938). General Motors Corp., *Composite Metallic Articles For Friction Elements.* A powdered layer of Cu-Sn is sintered on a sheet backing to produce a friction member.

(5004) U. S. 2,152,611 (1939). C. E. Swartz (Cleveland Graphite Bronze Co.), *Composite Metallic Elements, Such as Brake and Clutch Parts.* A Cu-base powder is hot-pressed onto a steel backing.

(5005) U. S. 2,178,527 (1939). S. K. Wellman (S. K. Wellman Co.), *Composite Machine Element and Method of Making Same.* A process of making a composite friction machine element comprises compressing powdered Cu or Fe-Cu with minor amounts of Sn and graphite in a non-oxidizing atmosphere, such atmosphere being maintained while the facing is sintered and welded to an Fe backing member at a temperature below the melting point of the higher-melting constituent of the facing.

(5006) U. S. 2,191,460 (1940). J. S. Fisher (General Metals Powder Co.), *Article of Manufacture.* Clutch plates are made from powdered metal, *e.g.* Cu-Sn-Pb, bonded onto a steel backing.

(5007) U. S. 2,239,134 (1941). S. K. Wellman (S. K. Wellman Co.), *Sintered Friction Article.* A friction article is made from powders which are produced by chemical precipitation of Cu from its salt solution, separating the precipitated material and the intermixed oxide from the solution, checking this composition as to Cu and adding powdered substances necessary to establish the predetermined friction-producing composition before sintering.

(5008) U. S. 2,251,410 (1941). R. P. Koehring and A. R. Shaw (General Motors Corp.), *Multilayer Material Suitable for Automobile Clutch Plates Etc.* A layer of loose, non-compacted metal powder, such as Cu and Fe, is applied upon a reinforcing member of dense material.

(5009) Italian 396,574 (1942). Ringsdorff-Werke, *Coating of Brakes, Particularly Brake Shoes, with Synthetic Sintered Materials.* In order to eliminate the sensitivity of the coefficient of friction against layers of heterogeneous materials, and against the effects of humidity, such materials as metal powders, ground carborundum, and C are used in different combinations. C products may be impregnated with Fe powder. (*Cf.:* German 742,090 (No. 3949)).

(5010) U. S. 2,287,952 (1942). H. Tormyn (General Motors Corp.), *Brake Drums From Metal Such As Iron Powder.* A brake drum having an upwardly extending braking ring adjacent to the outer periphery of drum is made by pressing Fe powder under high pressure into an annular form and sintering.

(5011) U. S. 2,299,877 (1942). W. G. Calkins (Chrysler Corp.), *Porous Metal Frictional Element Suitable for Clutches and Brakes.* Loosely arranged particles of powdered metals of different melting points, such as Cu and Sn or Fe, are sprinkled on a backing of reinforcing sheet such as stainless steel, and bonded to the backing at a temperature between the melting points of the powdered metal and the backing; a friction-producing material such as finely divided asbestos is introduced between the voids of the layer and thereafter pressure is applied.

(5012) U. S. 2,332,737 (1943). J. T. Marvin and A. R. Shaw (General Motors Co.), *Laminated Friction Element.* Compressed Cu powder is bonded to a flat compressed porous Fe supporting member.

(5013) U. S. 2,333,387 (1943). E. G. Parvin (Syncro Machine Co.), *Pull Block.* A pull block for a wire drawing machine is composed of metal powders, such as Cd, Cu or Ag mixed with free C.

(5014) U. S. 2,369,502 (1945). F. S. Walker (Raybestos-Manhattan Inc.), *Friction Material.* A rigid molded friction element comprises at least 40% of powdered soft Fe, or Cu, Al and an alloy of Cu plus 5-25% of a heated hardened organic binder; the powdered metal produces a substantially continuous metallic film on the friction surface of the element.

(5015) U. S. 2,381,941 (1945). S. K. Wellman and C. B. Sawyer (S. K. Wellman Co.), *Frictional Apparatus.* The facing layer of a frictional apparatus is made of compacted metal powders, attached to a supporting member, so that the integrity will not be destroyed when subjected to high temperatures.

(5016) U. S. 2,388,187 (1945). M. Salle (Thermoid Co.), *Friction Facing Material.* Metal chips or powders are used in making friction facings for brake linings.

(5017) U. S. 2,389,061 (1945). J. Kuzmick (Raybestos-Manhattan, Inc.), *Powdered Metal Body and Method of Making Same.* A friction element comprises a friction facing of a compacted homogeneous mixture of a powdered metal and a ceramic binder in the fused or vitrified condition, the facing being united to a solid metal backing plate by the sintered metal particles and the ceramic binder.

(5018) U. S. 2,389,772 (1945). S. Gilbert (Bendix Aviation Corp.), *Clutch.* Clutch disks are formed of powdered bronze.

(5019) Brit. 575,929 (1946). Mallory Metallurgical Products Ltd., *Clutches.* A clutch is formed of a composition consisting of a refractory metal and Ag or an Ag alloy; an example is 61% Mo and 39% Ag.

(5020) Brit. 575,996 (1946). Mallory Metallurgical Products Ltd., *Clutches.* A clutch element is composed of a refractory metal or compound and Cu or Cu alloys; *e.g.*, 60% Mo powder with 2% resin is pressed and sintered; then 40% Cu powder is placed in contact with the sintered body and heated to 1300° C. (2370° F.) for impregnation.

(5021) Brit. 576,564 (1946). Bendix Aviation Corp., *Metallic Material in Friction Elements of Brakes.* The material is made by carburizing a soft low-carbon steel at 955° C. (1750° F.) for 3-6 hours to diffuse hard grains of Fe_3C into the surface, then spheroidizing the carburized steel at 650-705° C. (1200-1300° F.) for 6-10 hours.

(5022) U. S. 2,408,430 (1946). F. J. Lowey and C. H. Tower (S. K. Wellman Co.), *Friction Composition.* Powdered Cu, Sn or Fe are used as friction materials for brake linings.

(5023) Brit. 601,186 (1948). S. K. Wellman Co., *Lining Brake Drums with Metal Powder.* Cu-plated drums are screwed inside of a furnace; a powder mixture of 73% Cu, 14% Pb, 7% Sn, 6% graphite is pressed against the drum and the temperature raised to 870° C. (1600° F.).

(5024) Brit. 610,509 (1948). Raybestos-Manhattan Inc., *Friction Element.* Clutch and brake linings are made by pressing a mixture of 68.5% Cu, 17.5% asbestos, 3.5% graphite, and 10.5% binder, at 3500 psi and heating to cure the binder.

(5025) Brit. 628,110 (1949). The S. K. Wellman Co., *Sintered Friction Material.* The inclusion of Mo sulfide in brake lining compositions increases the coefficient of friction, especially at higher speeds. A typical composition is 74% Cu, 5% Sn, 8% Fe, 4% silica, 9% graphite and 6% Mo sulfide lubricant.

(5026) Brit. 629,291 (1949). The S. K. Wellman Co., *Making a Multiple Layer Unit from Powders for Friction Disks.* Cu powder in a rotating annular mold is lightly compacted; a powdered mixture of friction material is then compacted on to the Cu powder in the same way, after which a separator disk is placed in position and the process repeated until the mold is filled.

(5027) U. S. 2,464,437 (1949). D. E. Dasher (Bendix Aviation Corp.), *Porous Metallic Structure and Method of Making Same.* Metal shot and metallic powders are used in making a porous metallic structure for brake linings.

(5028) U. S. 2,470,269 (1949). R. Schaefer (Cleveland Graphite Bronze Co.), *Friction Material.* The friction material consists of a mixture of powdered Cu, Sn, Pb, graphite and the oxides of the elements Al, Si, Ca and Fe; it is compressed and sintered together into a unit mass.

(5029) U. S. 2,475,264 (1949). W. C. Sutton (The S. K. Wellman Co.), *Flexible Belt.* The frictional faces of the metal belt or chain may be of any metal powder having the requisite strength and frictional properties. One suitable mixture comprises Cu, Sn, Pb, Fe, C, and SiO_2, and may be pressed and sintered and brazed to other portions of the belt or chain.

(5030) U. S. 2,480,076 (1949). F. De Marinis (The S. K. Wellman Co.), *Method of Manufacturing Friction Plates.* A briquette of powdered metal is placed on each prepared surface of a core to form a plate assembly and pressed at 110-250 psi at 790° C. (1450° F.); the assembly is placed between two separators or separator plates of a material that has a low coefficient of expansion. A material claimed comprises 25-35% Cr, 3-5% Ni, 0.15% C and the remainder principally Fe.

(5031) U. S. 2,483,996 (1949). F. De Marinis (S. K. Wellman Co.), *Method of Reconditioning Backing Members Having Powdered Material Facings.* In a process of reconditioning backing members of Fe which are Cu-plated and to which are bonded layers of defective sintered powdered metal mixtures, NaCN is used.

9. DENTAL ALLOYS

(5032) U. S. 56,765 (1866). E. Lamm, *Gold for Dentists.* Au for fillings is precipitated in form of metallic leaves from a solution of Au in 1:3 HNO_3–HCl by boiling with sugar; it is then washed with NH_3 and purified by heat.

(5033) U. S. 65,398; 65,399 (1867). E. Lamm, *Gold for Dentists.* Au shreds for dental use are precipitated from a solution of Au in 1:3 HNO_3–HCl by sugar or gum arabic as precipitant.

(5034) U. S. 157,140 (1874). S. S. Southworth, *Dental Amalgam.* An amalgam of Ag, Sn and Hg is filed to powder which then is pressed into pellets for fillings.

(5035) U. S. 168,680 (1875). L. W. Sutton, *Dental Fillings.* Sn is deposited in spongy crystals on a strip of Zn from a solution of Zn salt and used as fillings.

(5036) U. S. 324,650 (1885). S. P. Buatt, *Gold Amalgam.* Amalgams for dental fillings are produced from powdered Au combined with Hg, S and chalk and worked into a plastic mass.

(5037) U. S. 485,280 (1892). G. Jueterbock, *Amalgam.* The amalgam is made by rolling an Ag-Sn alloy into sheets and electroplating the sheets with Au; the sheets are then cut into small pieces.

(5038) U. S. 475,382 (1892). C. Carroll, *Dental Amalgam.* A dental amalgam is made of a powdered alloy of Ag, Sn, Cu and Al.

(5039) U. S. 532,724 (1895). J. G. Dennis, *Dental Amalgam.* Comminuted Cu is mixed with gutta percha to make fillings.

(5040) U. S. 612,593 (1898). P. Mertes, *Apparatus for Reducing Dental Metals.* An ingot is shaved by a hand-cranked rotary cutting tool in the preparation of amalgam fillings for teeth.

(5041) U. S. 819,249 (1906). C. Osius, *Dental Fillings.* Dental fillings are composed of powdered Au and Zn cement.

(5042) U. S. 1,040,838 (1912). C. L. Alexander, *Filling for Teeth.* Fillings are composed of powdered Au and a waxy binder.

(5043) U. S. 1,215,678 (1917). M. Marouke, *Dental Amalgam.* Powdered Au, Ag and Cu are mixed with Hg and dried to a powdered state.

(5044) Brit. 185,125 (1923). J. Maurer and H. F. Jakobsen, *A Method for Filling Cavities in Natural Teeth with Metal.* Metal foil or powder is filled into teeth and pressed by means of stopping pencils formed as electrodes and sintered by short current impulses.

(5045) U. S. 1,473,482 (1923). P. Krueger, *Filling Material.* A filling of dry Ag powder is mixed with a nonbinding solution of a germicide in water.

(5046) U. S. 1,574,714 (1926). C. C. Vogt (Lee S. Smith & Son Mfg. Co.), *Dental Alloy.* Ag and Sn plus a small amount of Cr, W, or V is powdered and mixed with Hg.

(5047) U. S. 1,612,782 (1926). C. C. Vogt (Lee S. Smith & Son Mfg. Co.), *Dental Alloy.* The alloy consists of powdered Ag and Sn plus a small amount of Ni or Co.

(5048) Brit. 238,488 (1928). E. W. Fischer and E. W. J. Virgin, *Production of Dental Amalgams.* Grains of Ag-Sn alloy powder are treated with Hg in quantity sufficient to amalgamate the alloy, but insufficient to produce adhesion of the grains.

(5049) Brit. 307,011 (1929). F. Hauptmeyer, *Alloy for Teeth-Fillings.* Steel with 20% Cr and 7% Ni is mixed with cement for teeth-fillings.

(5050) German 488,471 (1929). E. W. Fischer, *Production of Dental Amalgam.* In order to facilitate the amalgamation of dental cements, metal powder particles, *e.g.* Zn or Ag-Zn, are coated with Hg by mixing them with HgCl and HCl.

(5051) U. S. 1,803,386 (1931). E. W. Fischer, *Dental Alloy.* A filling of 50% dental cement and 50% powdered Cr-Ni-Fe or steel alloy is neutral to chemical agents.

(5052) French 761,496 (1934). A. W. Gray, *Dental Amalgam.* A mixture of Ag, Sn, Cu and Zn is crushed to pieces below 0.1 mm diameter, to permit easy and uniform mixing with Hg.

(5053) U. S. 1,963,085 (1934). A. W. Gray, *Dental Amalgams.* A comminuted alloy of metals for dental amalgams is made of fine powders which will expand during hardening when combined with Hg.

(5054) Brit. 442,773 (1936). A. W. Gray, *Comminuted Alloy for Dental Amalgams.* Particles of Ag, Sn, Cu have dimensions between 0.1-0.01 mm.; the thickness is about one third of the length.

(5055) German 636,998 (1936). Baker and Co., *Method of Producing Gold-Sponge for Filling Teeth.* Au-sponge for filling teeth is produced from a solution of $AuCl_3$ containing 28-56 g/l. Au; the solution is mixed with precipitant in excess, and the precipitate of Au is heated to 150° C. (300° F.).

(5056) U. S. 2,206,502 (1940). H. A. Heiligman (Nobilum Products Inc.), *Dental Alloys.* Metallic dentures are composed of a compressed mixture of metal powders of Cr, Ni and W, which may be cast.

(5057) German 714,164 (1941). W. Lohmann, *Production of Artificial Dental Parts.* Refractory metal powders, such as 18-8 stainless steel, are made plastic by mixing them with vaseline; the mixture is then deposited on a pattern which is removed after sintering.

(5058) U. S. 2,281,991 (1942). P. Poetschke, *Dental Amalgam.* A dental alloy of 80-95% Au is mixed with 20-5% comminuted performed hardened Ag amalgam.

(5059) U. S. 2,315,876 (1943). C. S. Sivil, E. O. Liebig and R. S. C. Low (Baker & Co.), *Casting Alloys Such as Those for Dentures.* Finely divided, mixed powders of 75% Au, 14% Ag, 8% Cu and 3% Pt are heated to produce a sintered friable cake and effect initial diffusion of the metals. The sintered cake is comminuted and compressed into shaped units of predetermined weight, heated to produce a coherent bonded mass of diffusion alloy, and then melted and cast.

(5060) U. S. 2,458,692 (1949). J. H. Downer, *Device for Mixing Dental Amalgams.* The apparatus consists of an amalgam mixing chamber within the reciprocable core of a solenoid magnet, enclosing a loose impact member or ball and providing a switch mechanism. An adjustable thermostatic cut-off automatically stops operation of the device when the powdered Ag and Hg amalgam is ready, *i.e.*, when the temperature of the coil exceeds a predetermined value.

10. MISCELLANEOUS APPLICATIONS FOR METAL POWDERS

A. Molded and Sintered Products

i. Combinations with Plastics

(5061) U. S. 1,771,615 (1930). J. Brincil, *Porous Bearing Bodies of Resinous Type.* Porous bearing bodies are made by mixing a resinous product with a lubricant and Zn powder, molding the mixture by means of heat and pressure and immersing the molded product in a bath of acid to dissolve the metal powder.

(5062) U. S. 1,953,111 (1934). H. F. Horne (Westinghouse Electric & Mfg. Co.), *Producing Laminated Resinous Material.* An article having a heat-hardening resinous base with a pigmented surface is produced by impregnating a fibrous sheet with a phenolic resin and a coating of a mixture of alcohol and metal powder.

(5063) Austrian 143,949 (1935). Elektrische Glühlampenfabriken Joh. Kremenezky A. G., *Production of Electrically Resistant Bodies.* The bodies consist of a metal powder, *e.g.* Mo, Ag, Al, mixed with a hardenable synthetic resin; the mass is pressed after hardening.

(5064) French 843,759 (1939). S. A. Cie. Des Meules Norton, *Moldable Material of a Metallic Aspect.* Moldable material consists of Al with 25% resin and is hot-pressed in a mold to consolidate the mass.

(5065) Brit. 519,539 (1940). Norton Grinding Wheel Co., Ltd., *Molded Articles.* Finely divided Al powder is mixed with not more than 25% of its volume of finely divided resin; the mixture is pressed in a mold to the desired shape.

(5066) U. S. 2,259,846 (1941). S. Vernet and J. L. Leiseron, *Temperature Responsive Element.* A plastic thermostatic material is formed from metal powders and diphenyl or dibromobenzene and used as a temperature responsive element.

(5067) U. S. 2,317,987 (1943). V. J. Flynn (Wardlyn Corp.), *Surgical Device.* A catheter is formed by extruding a thermoplastic mass containing Pb powder.

(5068) U. S. 2,332,829 (1943). J. A. Parson (American Plastic Corp.), *Casein Plastics.* Al bronze powder is incorporated in casein plastics to produce a pearl-like effect for ornaments.

(5069) U. S. 2,352,285 (1944). B. A. Proctor, *Phonograph Record Stampers.* Metal powders are contained in a thermosetting plastic material.

(5070) U. S. 2,367,296 (1945). R. P. Lutz (Western Electric Co.), *Leaded Phenol Resins.* Pb-phenol resins are produced by adding finely divided C black to a resinous material containing Pb particles.

(5071) U. S. 2,377,153 (1945). P. V. Hunter (Callenders Cable & Construction Co.), *Electric Cable.* An insulated electric cable utilizes conductive metal powders in a plastic material.

(5072) U. S. 2,384,521 (1945). B. Andersen and R. F. Strasdin (Celanese Corp.), *Thermoplastic Composition.* Al powder is used as a pigment in cellulose thermoplastic.

(5073) U. S. 2,387,783 (1945). G. L. Tawney (Sperry Gyroscope Co.), *Transmission Line.* Powdered Fe is used as a magnetic element and combined with Bakelite in forming an electric transmission line.

(5074) Brit. 581,184 (1946). Marconi Wireless Telegraph Co., *Electric Insulating and Dielectric Material.* -300 mesh Cu or Ag powder is mixed with polystyrene in proportions of 10-70% and molded for use as a dielectric material in radar apparatus.

(5075) U. S. 2,393,541 (1946). F. Kohler (Induction Heating Corp.), *Inductive Heating.* Metal powders and resin glue are combined to secure nonconductors; the device is heated so that the whole article becomes a nonconductor.

(5076) U. S. 2,396,629; 2,400,091 (1946). J. Alfthan and J. L. Chynoweth (E. I. Du Pont De Nemours & Co.), *Plastic Articles.* Powdered Cu, Fe or Pb are used as fillers in making shaped articles of polytetrafluoroethylene.

(5077) U. S. 2,398,703 (1946). H. A. Gardner, *Porous Compositions.* A porous rigid dielectric metalloidal body, characterized by a honeycomb structure and an apparent density less than that of water, consists of 10%-50% of finely divided particles of Al and Mg bonded together with an acidic resinous reaction product of maleic acid.

(5078) U. S. 2,400,099 (1946). M. M. Burbaker and E. H. Hanford (E. I. Du Pont de Nemours & Co.), *Molding Process.* A molded polymer of polytetrafluoroethylene includes mixtures of powdered Cu, Fe, or Pb.

(5079) U. S. 2,403,657 (1946). R. L. Harvey (Radio Corp. of America), *Insulating Material.* An electrical insulating and dielectric medium of polystyrene contains powdered Ag or Cu.

(5080) U. S. 2,406,428 (1946). C. Luckhaupt (A. R. Southworth), *Metal-Containing Plastic Combination.* A plastic composition comprises a homogeneous aggregate of 49%-59%, PbO, 23%-33% finely divided metallic particles, and 15%-26% glycerine.

(5081) U. S. 2,409,505 (1946). G. M. Magrum (Houdaille-Hershey Corp.), *Hydraulic Shock Absorber.* Powdered Al is incorporated in a lightweight plastic used to mold a shock absorber.

(5082) U. S. 2,431,260 (1947). B. F. Langer (Westinghouse Electric Corp.), *Torque Measuring Device.* A sleeve of Cu is placed above the shaft whose torque is measured; about the sleeve and bonded to it is an insulating layer of Fe powder mixed with resin, and a winding of strain-reactive material is fixed on the insulating layer.

(5083) Brit. 605,145 (1948). General Motors Corp., *Improved Thermo-Sensitive Material.* A material for thermostatic switches is made by sintering a layer of a coarse powder to a steel sheet; a layer of thermosetting resin is then imposed upon the porous sintered layer.

(5084) Brit. 605,597 (1948). H. Weber, *Synthetic Resinous Molding Composition.* The material is composed of 100 parts resin, 35-50 parts casein, 35-50 parts ground Al dross or powder, 35-50 parts sawdust, 5-10 parts lime, and 10-15 parts hexamine.

(5085) U. S. 2,438,926 (1948). E. E. Mott (Bell Telephone Laboratories), *Supersonic Submarine Signaling Device.* The core is cast or molded integral with a body which reinforces the core against parasitic vibratory moves; the body is made of plastic, such as a phenolic condensation product, in which Cu dust is dispersed.

(5086) U. S. 2,439,137 (1948). A. V. Keller (Thompson's Ltd.), *Laminated Plastic Article.* A heat insulating material is made by interposing a sheet of Al between two resin impregnated sheets of fabric, coated with metal powder.

(5087) U. S. 2,456,919 (1948). L. Coes (Norton Co.), *Improving the Water-Resistance of Resin.* The production of an aniline formaldehyde resin, suitable for use for grinding wheels, comprises mixing reactive aniline formaldehyde with a polyglycol dichloride and with a powdered metal, *e.g.*, Pb, Fe, Zn or Cu, pressing and curing the mix. The HCl released during the curing forms metal chlorides with the metallic particles.

(5088) U. S. 2,464,989 (1949). F. E. Payne, *Shaft Seal with "O" Ring.* A seal for use between the shaft and housing of pumps has a sealing washer made of a resin impregnated with a powdered metal alloy.

(5089) U. S. 2,470,264 (1949). L. D. Richardson (Hansen Mfg. Co., Inc.), *Electric Motor Bearing.* A combined magnetic core and bearing is formed of a plastic bonded metal powder and a quantity of graphite powder or flakes. The bearing is free from expansion and contraction due to varying temperatures, requires no liquid lubricant, and may be molded to a very accurate size.

(5090) U. S. 2,472,247 (1949). E. J. Coleman (Crane Packing Co.), *Fast-Setting Compound of Resin and Powdered Metal.* The composition is useful for forming anti-friction bearings, sealing washers and may be prepared by mixing 35-50% phenolic resin, 22-30% asbestos filler, and 13-15% graphite; a powdered metal alloy of 80-85% Pb and the remainder Sb and Sn and a lubricant are added.

ii. Jewelry, Medals, and Coins

(5091) U. S. 2,126,737 (1938). G. J. Comstock (Handy and Harman), *Inlaid Articles Such as Silverware and Jewelry.* Porous Ag and Cu products are made from powders, and an adhesive binder, such as gum, may be used to facilitate forming.

(5092) U. S. 2,350,421 (1944). W. P. Schoder and J. P. Ruth, *Inlaid Jewels.* A jewel consists of a mosaic pattern of metallic particles embedded in a molded plastic body.

(5093) U. S. 2,365,083 (1944). T. C. Jarrett (American Optical Co.), *Gold-Filled Wire.* An Au filled wire for use in the optical trade has a core of metal powders to decrease the density.

(5094) U. S. 2,389,981 (1945). T. C. Jarrett (American Optical Co.), *Gold-Filled Wire.* An Au-filled wire has powdered metal as a core.

iii. Laminated Structures and Bi-Metallic and Composite Products

(5095) U. S. 1,390,243 (1921). C. A. Laise (General Electric Co.), *Method of Welding Low Melting Point Metal.* Powdered material of a low melting point is pressed on a plated material and heated.

(5096) U. S. 1,703,177 (1929). C. R. Short, *Bearing and Method of Making the Same.* The bearing is composed of finely divided particles of Al secured to the steel back by the application of high pressure and accompanied by heating.

(5097) U. S. 1,766,865 (1930). H. M. Williams and A. L. Boegehold (General Motors Research Corp.), *Alloy Structure Adapted for Use in Conjunction with Other Rubbing or Sliding Contacts.* A hollow cylinder of peripherally laminated structure is composed of a non-porous strong metallic lamination and another of a porous alloy, secured together by an alloy bond.

(5098) U. S. 1,797,752 (1931). L. Blackmore, *Bearing.* A blank is bent to the desired curvature to form a bearing back; it is placed in a die, soft metal is poured into it, and pressure is applied to cause the bearing metal to adhere to the backing.

(5099) U. S. 1,819,272 (1931). C. Short (Moraine Products Corp.), *Bearing.* Composite bearings are made by welding a preformed porous metallic lining to a reinforcing member through holding them together and heating.

(5100) U. S. 1,834,746 (1931). C. Short (Moraine Products Corp.), *Bearing.* A bearing comprises a reinforcing member secured to a metallic facing formed of layers differing in porosity.

(5101) Brit. 369,964 (1932). I. G. Farbenindustrie A. G., *Production of Porous Or Non-Porous Articles.* A process for the manufacture of metal articles consists of arranging mixtures of two different metal powders in a number of layers which differ from each other in composition, subjecting the whole to a sintering treatment alone by heating, then subjecting to a compression and molding treatment to form a metallic article.

(5102) German 550,740 (1932). Siemens & Halske A. G., *Wall for Safes.* The wall consists of a metal plate weaving on whose inner side a layer of hard metal carbides is joined by welding, and cast over with a layer of Cu.

(5103) U. S. 1,853,385 (1932). W. P. Spade and J. H. Spade, *Making Molds of Alloys.* A process of producing a mold comprises forming a pattern of steel containing 5% Si, 9% Cr and 0.5% C, compressing particles of Fe, having a C content adapting them to be hardened by heat treatment into a coherent mass, impressing the pattern in the particles and thereafter subjecting the whole to a heat treatment in contact with molten Cu in the presence of H_2.

(5104) U. S. 1,892,172 (1932). B. Stockfleth (Cleveland Graphite Bronze Co.), *Composite Bearing Sleeves.* A hard metal back is Sn-plated to cause a bond between the back and a Babbitt lining, then the sleeve is placed between heated die members and pressed to thin and simultaneously form the bearing member.

(5105) German 580,408 (1933). Siemens & Halske A. G., *Wall for Safes.* Addition to German 550,740 (No. 5102). The back side of the metal plate consists of a sintered mixture with more than 50% TiC.

(5106) U. S. 1,896,939 (1933). W. G. Calkins (Chrysler Corp.), *Bearings.* Bearings are manufactured by sintering compressed powdered metals in the opening of connecting rod bearing.

(5107) U. S. 1,920,022 (1933). W. J. Six (Cleveland Graphite Bronze Co.), *Bearing Manufacture.* The production of lined cylindrical bearings comprises bonding powdered metal to the inside of a cylindrical shell of a stronger metal of higher melting point by heating.

(5108) German 598,766 (1934). I. G. Farbenindustrie A. G., *Production of Metal Compounds as Plated Articles.* Powdered metal for plating or cladding is produced from metal carbonyls which are heated and pressed onto the backing material.

(5109) U. S. 1,969,396 (1934). F. Duftschmid (I. G. Farbenindustrie A. G.), *Metallic Articles Such as Sheets for Stamping and Rolling.* Metallic bodies are produced by arranging a layer of Cu powder adjacent to a layer of Fe powder and sintering the mass by application of heat alone.

(5110) U. S. 1,979,498 (1934). C. R. Short (General Motors Corp.), *Composite Piston.* A cast main body of Al has a lubricant-impregnated porous bronze plate bonded to the piston skirt by an intervening thin layer of Zn, which is moleculary alloyed with both.

(5111) Austrian 143,627 (1935). A. Kratky, *Laminated Sintered Hard Alloys.* Sintered hard carbides or nitrides, cemented with Co, Fe, Ni or Cr, are superimposed in layers on top of each other; each layer is specially heated.

(5112) German 612,880 (1935). P. Schwarzkopf (N. V. Molybdenum Co.), *Laminated Metal Bodies for Electric Purposes.* An alloy of Mo, W, or Ta plus Ag, Al, Co, Fe, or Ni is produced by coating the metals of the 1st group with a layer of a metal of the 2nd group, or by pressing different layers of metals of the 1st and 2nd group.

(5113) German 618,063 (1935). I. G. Farbenindustrie A. G. and F. Duftschmid, *Composite Metal Articles.* A metal article which can be worked, is plated with layers of different metal powders, such as Fe and Ni, which are sintered together with the article.

(5114) Austrian 146,183 (1936). F. F. Gordon, *Production of Composite Metal Parts.* The metal parts are joined by using an interposition of powdered Mn or Mn alloy mixed with Ni, Fe, Co, Cr, and pressed and sintered.

(5115) Brit. 446,063 (1936). A. Kratky, *Coherent Multiple-Layer Bodies From Powdered Metals and Alloys.* Carbides are sintered in layers and pressed together, one at a time, into laminated structures suitable for tools.

(5116) Brit. 455,910 (1936). British Thomson-Houston Co. Ltd., *Multiple Layer Metal Cutting Tool Bits.* A body consisting of multiple layers, one consisting of Co-cemented TaC, another of Co-cemented WC and an intermediate of a mixture of both is used for cutting tools.

(5117) Swedish 88,112 (1936). A. Kratky, *Laminated Sintered Hard Alloy. Cf.:* Austrian 143,627 (No. 5111).

(5118) U. S. 2,033,240 (1936). C. Hardy (Hardy Metallurgical Co.), *Composite Metal Articles.* Bearings or other articles are made from two or more metals which do not alloy and have different melting points; a mass of plated powder having cores of lower melting point and coatings of higher melting point metal (*e.g.*, Cu-coated Pb) is compressed and sintered. The mass may be bonded to a steel backing.

(5119) Brit. 459,336 (1937). Hardy Metallurgical Co. and C. Hardy, *Composite Metal Article. Cf.:* U. S. 2,033,240 (No. 5118).

(5120) Brit. 463,775 (1937). Hardy Metallurgical Co. and C. Hardy, *Composite Metal Articles.* Plated metal powders having a core of a low melting point metal and a coating of a higher melting point metal are formed to a coherent mass and fastened to a metal backing by pressure, and simultaneously heated to a temperature intermediate to the two melting points, to weld the mass to the backing.

(5121) Brit. 470,133 (1937). H. Bass (N. V. Molybdenum Co.), *An Improved Process for Making Bearings from Powdered Metals and Metalloids.* A bearing comprises a mixture of metal and non-metal particles consolidated under heat and pressure in layers.

(5122) German 645,049 (1937). Heraeus-Vacuumschmelze A. G. and W. Rohn, *Metal Strip with Curvature Dependent on Temperature.* The coefficient of expansion is changed sensitively along the cross section of the strip by changing the composition of the metal; different mixtures of Ni, Fe, Mo powders in different layers are sintered together for the purpose.

(5123) Austrian 152,806 (1938). N. V. Molybdenum Co., *Bearings Produced from Mixtures of Metal Graphite Powders and Metalloid Powders.* The body, *e.g.* a bearing, is formed of two layers; one of them, exposed to friction, has a higher content of metalloid, *e.g.* graphite, than the supporting layer, which must have a higher strength.

(5124) Brit. 491,416 (1938). Wuppertaler Metallverarbeitungsgesellschaft m.b.H., *Making Compound Metal Articles.* A porous metal layer is united with a metal body by pressing metal powders in a layer on the body, then exposing the product to an electric eddy current of high frequency, which sinters the metal particles to the body.

(5125) French 823,239 (1938). N. V. Molybdenum Co., *Bearing.* The bearing consists of a pressed and sintered mixture of metal particles and non-metal particles used as lubricant, with zones of different composition, arranged so that the zone of friction contains more non-metallic particles. For example: 90% brass, 8% Ni, 2% graphite is used for the body, while the surface contains 88% brass, 2% Ni, and 10% graphite.

(5126) French 829,933 (1938). Wuppertaler Metallverarbeitungsgesellschaft m.b.H., *Compound Metal Articles. Cf.:* Brit. 491,416 (No. 5124).

(5127) Canadian 389,889 (1939). General Motors Corp., *Bronze Bearings.* An Fe band is first coated with Pb, then bronze powder is sintered onto the band.

(5128) German 675,871 (1939). Stahlwerke Röchling-Buderus A. G., *Sintered Composite Metal Body.* A composite structure mainly suitable for cutting tools is produced from Fe, Ni, Cr, Co, V, Mo, or W powder mixed with up to 15% of a tempering alloy of Cu with 0.3-7% Be, pressed and sintered at 900-1200° C. (1650-2190° F.), quenched and annealed between 300° C. (570° F.) and 900° C. (1650° F.).

The major constituent may also be Ta or TaC, and the sintered composite bodies may also contain C and/or B or Si for purposes of precipitation hardening.

(5129) Swiss 203,738 (1939). A. Kratky, *Method for Production of Formed Bodies of Hard Alloys.* Porous briquettes from metal powders are coated with a mixture of a metal powder and a hard carbide powder, then heated up to the melting point of the coating to sinter and infiltrate the pores of the briquette and to produce complicated bodies.

(5130) U. S. 2,152,611 (1939). C. E. Swartz (Cleveland Graphite Bronze Co.), *Composite Metallic Elements.* Composite metallic elements are made by Cu-plating a steel supporting element, covering it with metal powders, compressing, forming and heating.

(5131) U. S. 2,158,461 (1939). R. P. Koehring and J. M. Hildabolt (General Motors Corp.), *Method of Making Bearings.* A bronze Pb bearing lining with Fe-metal backing is formed from metal powders which are compacted directly upon the backing strip by high pressure and thereafter sintered, whereby the parts are strongly bonded together.

(5132) U. S. 2,161,597 (1939). C. E. Swartz (Cleveland Graphite Bronze Co.), *Bonding Powdered Metallic Material Such as Al and Cu to Steel.* A method of bonding powdered metallic material to steel comprises cleaning the surface of steel, applying a covering layer of powdered Cu or Al, then subjecting the covered steel to compression and a temperature sufficient to sinter the Cu or Al to the steel and to cause diffusion.

(5133) U. S. 2,187,348 (1940). F. Hodson, *Composite Metal Bearing.* A bearing is produced by applying heat and pressure to a base coated with a spray of initially solid material in the thermoplastic state.

(5134) U. S. 2,198,253; 2,198,254 (1940). R. P. Koehring (General Motors Corp.), *Composite Bearing Elements.* A porous Cu lining is produced on a metal back by applying a loose layer of Cu powder, heating the composite to cause sintering; Pb is then applied to the surface of the porous lining and impregnated by heating.

(5135) U. S. 2,198,654 (1940). W. G. Calkins and C. Breer (Chrysler Corp.), *Splined Coupling.* In a composite, splined joint of a coupling, some splines comprise compressed and sintered metal powders.

(5136) U. S. 2,199,620 (1940). J. H. Davis (General Motors Corp.), *Method of Forming Porous Metal Articles into Composites.* Porous metal articles, *e.g.* bronze, Cu, Sn, Fe or Ni, comprising compressed and sintered metal powders, are fastened to a supporting member by placing in a die and compressing; the plugs are deformed, causing them to be fastened to the member, while at the same time their densities can be increased to a desired amount.

(5137) U. S. 2,221,983 (1940). P. Schwarzkopf and E. E. Mayer, *Laminar Magnetic Structure.* The structure is built up of layers of powdered Fe interlaid with insulating layers of inorganic mineral oxide particles.

(5138) U. S. 2,222,251 (1940). W. G. Calkins and A. J. Langhammer (Chrysler Corp.), *Method of Making Bearings.* Bearings are made by applying compressed powdered metal to a sheet metal backing by sintering and bonding together.

(5139) U. S. 2,225,269 (1940). J. M. Hildabolt (General Motors Corp.), *Method of Making Composite Strip Material.* Flat composite stock for use in bushings comprises a layer of sintered metal bonded to a strong metal supporting back.

(5140) U. S. 2,226,263 (1940). L. Sandler and L. G. Klinker (Johnson Bronze Co.), *Method of Making Steel Backed Bronze Bearings.* A steel backed composite bronze bearing is produced by sintering.

(5141) Brit. 538,128 (1941). Johnson Bronze Co., *Making of Bronze Bearings.* The process comprises grinding a pre-cast Pb-containing bronze to powder, applying the powder to a steel backing and sintering.

(5142) Canadian 439,772 (1941). General Motors Corp., *Sintering of Powdered Metal Briquettes.* A continuous strip of composite porous bearing material is made by feeding two layers of loose powders upon endless belt conveyors and compacting the powders by passing them through a sintering furnace.

(5143) U. S. 2,234,371 (1941). E. Fetz (Hardy Metallurgical Co.), *Manufacture of Composite Bearings.* The process consists of placing powdered Cu on a metal

back to form an uncompacted coating, heating to below the melting point of Cu until the Cu particles become bonded to each other to form a porous matrix welded to the backing, then hot-compressing a layer of Cu-coated Pb powder to the matrix until the Pb sweats out and impregnates the matrix to yield a fully dense product.

(5144) U. S. 2,241,094; 2,241,095 (1941). J. T. Marvin (General Motors Corp.), *Continuous Process of Sintering Porous Articles.* A porous layer of metal powder on a metal band conveyor is passed through a sintering furnace whereby the powder is sintered and bonded to the supporting back; the layer is compacted while hot.

(5145) U. S. 2,260,247 (1941). E. R. Darby (Federal Mogul Corp.), *Bearings.* Bearings with steel backs and Cu-base alloy linings are produced by sintering.

(5146) Brit. 545,522 (1942). R. F. Knowlson, *Cast or Molded Machine Parts.* The parts have incorporated in the mass, *e.g.* bronze, small particles of a hard metal, *e.g.* WC powder with 6% Co, constituting a composite structure.

(5147) Swedish 106,354 (1942). Deutsche Edelstahlwerke A. G., *Process for Manufacture of Composite Bodies.* Composite bodies consist of at least two substances having different melting points, the one with the lower one being a metal. A thorough mix of different-size grains, uniformly distributed, in the form of a loose powder, is prepared first, compacted and then sintered without any portion being in the liquid state; this compact is then mechanically compressed at a higher pressure and at an elevated temperature.

(5148) U. S. 2,289,152 (1942). M. Telkes (Westinghouse Electric & Mfg. Co.), *Use of Powdered Material Such as Zinc and Antimony in the Manufacture of Bimetal Thermocouples.* The process involves sintering a mixture of two powdered materials in a confining insulating jacket, by applying pressure to a conducting strap disposed on the mass of powder to force a projection on the strap into the jacket to make electric contact.

(5149) U. S. 2,289,311 (1942). S. K. Wellman (S. K. Wellman Co.), *Composite Blank.* A method is described for shaping composite articles composed of sintered lamina bonded to a metallic backing.

(5150) U. S. 2,289,658 (1942). R. P. Koehring (General Motors Corp.), *Composite Metal Products.* Composite metal products on a steel supporting backing element are made by uniformly distributing on the backing a non-compacted alloyable metal powder, such as 90% Cu and 10% Sn, held in place by gravity, heating the element with the powder thereon to alloy it into a porous layer and bonding the layer with the element.

(5151) U. S. 2,290,338 (1942). R. P. Koehring (General Motors Corp.), *Composite Articles.* Powdered metal is sintered on a metal backing by electrically heating the composite.

(5152) German 742,007 (1943). W. Jaeger, *Manufacture of Steel-Backed Bearings.* Bearing surfaces are centrifugally cast by heating screw-wise rotating powder-coated bushes by means of a stationary arc.

(5153) German 742,965 (1943). Heraeus-Vacuumschmelze A. G., *Material Resistant to Molten Zinc.* The material consists of Mo or Mo alloys with up to 20% Fe; structural parts are joined by pressing and sintering of layers of Fe powders between the parts.

(5154) U. S. 2,307,874 (1943). T. E. Bilde, *Process for Manufacturing Bearings.* The manufacture of a sleeve bearing comprises molding an outer bearing ring element of nonmetallic material around an inner ring of metal powders.

(5155) U. S. 2,330,018 (1943). L. R. Van Wert (Leeds & Northrup Co.), *Thermocouple Element.* A bimetal alloy comprising Cu and Ni with 10% Al powders is used in a thermocouple element.

(5156) U. S. 2,331,584 (1943). A. F. Underwood (General Motors Corp.), *Composite Metal Articles Such as Connecting Rods of Internal Combustion Engines.* A composite bearing consists of steel backing and a porous Cu-base powder structure adhering to it which is obtained by filling the powder onto the backs in dies and heating the composite structures without application of pressure and then heat treating.

(5157) U. S. 2,332,746 (1943). R. G. Olt (General Motors Corp.), *Method of Making Porous Metals.* Porous material is made by distributing metal powders upon metallic strip material and simultaneously serrating or grooving the metal powder layer.

(5158) Swiss 233,609 (1944). H. Vogt, *Production of Sintered Composite Bodies.* The body consists of two concentric rings, *e.g.* bushes of Fe powder with different C contents, which are pressed together and joined during sintering.

(5159) U. S. 2,341,784 (1944). W. H. John (Aviation Corp.), *Composite Steel Propeller Blades.* Sintered alloys of powdered Cu, Ni, Zn and Sn are used as fillets in hollow steel propeller blades.

(5160) U. S. 2,350,971 (1944). J. S. Pecker and H. A. Simpson (J. S. Pecker), *Method of Forming Articles of Powder in Layers.* The method comprises applying forming pressure to layers of powder to form a pressure weld and compact the layers into a unit article; the concentration of powder is built up on areas of the mold cavity to strengthen the points of union during the pressure welding operation.

(5161) U. S. 2,352,206 (1944). G. H. Kendall, *Controlled Temperature Bearing.* A controlled temperature bearing has a backing material made of Zn, Mg or Al for whose manufacture powder metallurgy methods are particularly adapted.

(5162) U. S. 2,353,693 (1944). J. H. Church, *Rotating Band for Projectiles.* The manufacturing method comprises encircling the projectile with metal powder, compressing and simultaneously sintering the band to the wall.

(5163) U. S. 2,359,361 (1944). K. M. Gleszer and R. P. Koehring (General Motors Corp.), *Composite Metal Element and Method of Making Same.* Laminated material for clutches, bearings, etc. comprises a steel support, a Cu-Fe powder porous layer bonded to the steel, a Cu layer bonded to the porous layer with Ag adjacent to the Cu layer, and an Fe layer sintered onto the Cu layer with Ag acting as bonding agent.

(5164) U. S. 2,363,337 (1944). J. M. Kelly (Westinghouse Electric & Mfg. Co.), *Mold.* A mold of Cr or Ni is subjected to an Fe-plating process to form a thin film by electroforming; powdered Fe is applied to the back of the mold and impregnated with a lower melting metal, such as Cu.

(5165) Brit. 567,127 (1945). General Electric Co. Ltd., C. E. Ransley and S. V. Williams, *Metal Bodies Resistant to High Temperature.* A composite metal body resistive to chemical attack and creep at elevated temperatures consists of an outer part of a metal which is not appreciably oxidized at 700° C. (1290° F.), but is subject to creep, such as an alloy of Ni and Cr, and an inner skeleton of a metal free from creep but oxidizable at 700° C., such as a woven wire network of W; the body is produced by impregnating the latter with the former.

(5166) Brit. 568,786 (1945). W. D. Jones, *Composite Metal Article.* A powdered mixture of reducible metallic compounds of CuO and NiO is applied to a metal backing and heated in the presence of a reducing agent to 450° C. (840° F.); the temperature is then raised to 850-950° C. (1560-1740° F.) to complete the sintering.

(5167) U. S. 2,368,549 (1945). G. H. Kendall, *Flanged Bearings.* An antifriction bearing utilizes metal powders in the backing member to conduct heat away from the bearing.

(5168) U. S. 2,372,607 (1945). P. Schwarzkopf (American Electro Metal Corp.), *Method of Making Layered Armors.* Armor plate consists of a system of layers or strata of low-C steel interspersed with hard layers of carbides, nitrides and borides, preferably of Ti; W, Mo, Cr, Ta, Cb, V, Zr, B may also be used.

(5169) U. S. 2,374,747 (1945). C. Hardy (Hardy Metallurgical Co.), *Method of Making Tubular Bearings.* An annular lining for tubular bearings comprises a compacted layer of metal powders on the inside wall.

(5170) U. S. 2,390,343 (1945). J. E. Aske, *Piston.* Granular Cu is used as a top layer on a cast Fe piston.

(5171) Brit. 577,765 (1946). Tecalemit Ltd., *Reinforced Porous Metal.* The interstices of a wire gauze or mesh are filled with metal particles which are subsequently sintered.

(5172) Brit. 580,660 (1946). Glacier Metal Co. and J. Bate, *Composite Bearings.* The bearings are manufactured by sintering a 70:30 Cu-Pb layer to a steel backing, rolling first to 30% porosity, and then to 10% porosity, to cover at least 50% of the surface with indentations; the surface is then coated with Pb and the surface machined off to expose the sintered layer.

(5173) U. S. 2,392,917 (1946). E. J. Guinee (H. A. Wilson Co.), *Silver Cladding of Bearings.* Powdered Cu is used in the fabrication of bearings; a thin coating of Cu is formed on a steel backing by melting, and then Ag is pressed on the Cu-coated surface and heated to produce a Cu-Ag interface.

(5174) U. S. 2,404,808 (1946). F. J. Lowey (The S. K. Wellman Co.), *Method of Making Bearings.* Sintered annular cylindrical bearings consist of assemblies of individual annular pressings and a solid metal backing; the method involves bonding a metal powder bearing from a mixture of 80% Cu, 11% Sn, 3% Pb and 6% graphite onto the backing.

(5175) U. S. 2,409,307 (1946). E. S. Patch and W. T. Moore (General Motors Co.), *Projectile.* Powdered Fe and Ni are used to make a porous composite bullet impregnated with Pb.

(5176) Swiss 245,207 (1947). Aktiengesellschaft Brown, Boveri & Co., *Laminated Sintered Articles.* Electrodes in ionization chambers are made of alternate layers of metal powder separated by a ceramic insulating material.

(5177) U. S. 2,424,557 (1947). D. De Bra (General Motors Corp.), *Composite Metal Article.* Onto a metal backing is sprayed a layer of Cu to a thickness of 0.006-0.015 in., after which Cu powder is applied to a depth of 0.005-0.015 in.; Fe powder is then applied to a depth of 0.02-0.05 in.

(5178) U. S. 2,431,430 (1947). H. Shaw, *Bearing.* A bearing has a multitude of closely adjacent, minute pits in the surface, which are filled with a metal powder having lower heat conductivity than the metal of the matrix.

(5179) U. S. 2,431,975 (1947). H. P. Yokey and J. M. Nuding (U. S. A., as represented by the Atomic Energy Commission), *Method of Welding Carbon to Molybdenum.* C can be bonded to metals which form carbides that are soluble in the metals and absorbed in the porous structure of C; the bonding is performed by atomic H welding apparatus.

(5180) Brit. 595,920 (1948). The S. K. Wellman Co., *Method of Imparting Desired Shape to Bimetallic Articles.* Shaft bearings or brake shoes are made of metal-backed sintered material composed of 73% Cu, 14% Pb, 7% Sn, and 6% graphite and bent into shape by passing the flat strip through opposing rollers.

(5181) Brit. 596,922 (1948). Eaton Manufacturing Co., *Composite Metal Articles.* Valve heads are joined to stems by interposing a layer of high Ni-Cr steel powder and sintering.

(5182) Brit. 602,440 (1948). Elastic Stop Nut Corp. of America, *Self Locking Fastening Devices.* Self-locking nuts are made by providing a sintered insert of a mixture of electrolytic Fe with 3% Pb, compacted at 100 tsi and sintered at 1030° C. (1886° F.); the product has a good combination of hardness, elasticity and lubrication.

(5183) U. S. 2,434,237; 2,451,264 (1948). S. K. Wellman (The S. K. Wellman Co.), *Apparatus for Applying Metal Briquettes to Curved Surfaces.* The surface of a brake drum is metallized, the metal powder briquette is laid on that surface, and the two parts are pressed and heated for sintering.

(5184) U. S. 2,446,891 (1948). C.H. Tower and F.J. Lowey (The S.K. Wellman Co.), *Method of Bending Bimetallic Articles.* By controlled directional working of the sintered metal facing, the bimetallic strip is caused to assume a curvature, so that the sintered facing will be the convex surface.

(5185) U. S. 2,446,892 (1948). F. J. Lowey (The S.K. Wellman Co.), *Method of Shaping Bimetallic Articles.* The articles have a plastic facing metal bonded to a less plastic backing member by applying pressure to laterally extending areas successively and progressively along the length of the article and increasing the pressure from one side to the other, to elongate the more plastic facing.

(5186) U. S. 2,451,264 (1948). S. K. Wellman (S. K. Wellman Co.), *Applying Powdered Metal Briquettes to Curved Surfaces.* The compact is sintered and bonded to a thin steel sheet and curved to the curvature of the flange surface; the sintered layer is positioned between the flange and the reinforcing steel sheet, and then pressure is applied to the assembly, while simultaneously heating and sintering.

(5187) U. S. 2,455,804 (1948). C. E. Ransley and S. V. Williams (General Electric Co. Ltd.), *Nickel-Chromium-Tungsten Metal Body. Cf.:* Brit. 567,127 (No. 5165).

(5188) Brit. 609,504 (1949). Elastic Stop Nut Corp. of America, *Self-Locking Threaded Fastening Devices.* The nuts are pressed in one operation with two different layers of metal powder; one layer consists of electrolytic Fe or alloy steel powder, the second layer with a smaller bore is an Fe-Pb mixture or brass.

(5189) Brit. 618,009 (1949). Isthmian Metals, Inc., *Heat Treatment of Duplex Iron and Steel Bodies.* The Fe powder may be compacted into the groove on a shell at 90 tsi, followed by sintering at 980° C. (1796° F.) for 2 hours, quenching and drawing. Objects consisting partly of sintered steel and of sintered Fe should be heat-treated in N_2.

(5190) Brit. 619,634 (1949). N. P. W. Moore and P. Grootenhuis, *Internal Combustion Engines.* The porous surface of gas turbine blades is obtained by sintering metal powders to the solid core, by metal spraying, or by shaping porous sintered sheets.

(5191) Brit. 625,010 (1949). Aktiengesellschaft Brown, Boveri & Co., *Laminated Sintered Body for Electrical Apparatus.* The parts are built up from graded layers of metal powder, mixtures of metal powder and ceramic or glass; all these materials should have similar sintering temperatures.

(5192) Brit. 628,323 (1949). The S. K. Wellman Co., *Method of Bending a Bimetallic Article.* A mixture of 67.26% Cu, 5.31% Sn, 8.72% Pb, 7.20% Fe, 7.08% graphite and 4.42% silica is sintered on steel strips; the strips are then bent to shapes suitable for friction devices.

(5193) U. S. 2,461,765 (1949). R. G. Olt, (General Motors Corp.), *Method of Making Composite Bearings.* Cylindrical objects are produced from powdered metal by distributing the powders in a cylindrical form and, while being held in place centrifugally, sintering to form a porous metal cylinder. Sintering of the powdered metal is effected by use of induction heating. The method and apparatus are applicable to fabrication of bushings having a reinforcing metal back, in which case the powdered metal is distributed over the inner surface of a steel shell or tube.

(5194) U. S. 2,462,821 (1949). S. K. Wellman (The S. K. Wellman Co.), *Method of Making Composite Articles.* A metal powder mixture of suitable composition is applied to the interior surface of a hollow cylindrical backing member of solid metal which is rotated about its axis. Rotation and the centrifugal force developed are used to distribute the powder around the surface and to result in compaction and densification of the powder. While the member is still rotating, heat is applied to the powdered material to sinter it and cause it to bond to the backing member and form a friction lining.

(5195) U. S. 2,464,591 (1949). E. I. Larsen and E. F. Swazy (P. R. Mallory & Co., Inc.), *Method of Bonding a Tungsten Member to a Backing Member.* In the production of X-ray targets, a composition of W, Mo, and Ni is ball milled for 48 hours, impregnated with 1% Glyptal resin as a binder, and screened through a 90 mesh sieve; the powder is then pressed into disks and sintered. The liquid phase Ni-Mo, which exudes during sintering, is used as a constituent of the brazing medium, when heating the tungsten disk in contact with the base.

(5196) U. S. 2,465,329 (1949). W. S. Murray (The Indium Corp. of America), *Indium-Treated Copper-Clad Bearing.* A bearing is made by forming a Cu-clad steel and shaping it into a bearing. In is applied thereon by electroplating or powder metallurgy and a part of the In is diffused into the Cu by heating to a temperature above the melting point of In and well below that of Cu. A softer surface portion is left in which the In is not fully diffused into the Cu and which is higher in In content than an underlying portion.

(5197) U. S. 2,490,543 (1949). J. M. Robertson and H. W. Schultz (General Motors Corp.), *Method of Making Composite Stock.* The composite is made by the attachment of a sprayed Al layer to a steel backing member through the medium of a porous metal layer of Cu or Ni, which is spread on the metal strip and sintered.

(5198) U. S. 2,490,549 (1949). H. W. Schultz, J. M. Robertson and O. Rasmussen (General Motors Corp.), *Method of Making Composite Stock.* The composite stock may be used in bearing and clutch applications; the porous metal layer of non-compacted metal powder is applied to a steel layer by sintering.

iv. Extruded or Rolled Products

(5199) Brit. 247,507 (1926). General Electric Co. Ltd., *Thin Sheets of Tungsten.* In the last stage of working, W sheet is placed between two metal plates of Fe, united at their edges, but not soldered or in contact with the sheet.

(5200) U. S. 1,872,902 (1932). H. L. Crowley (Henry L. Crowley & Co.), *Molded Articles.* A mixture of a powdered metal compound plus a binder of a metal compound which can be produced in jell form is extruded or pressed and baked; for example, if a powdered metal oxide is used, a jell of the metal oxide is employed as binder.

(5201) German 693,032 (1940). Deutsche Eisenwerke A. G., *Shaped Molds from Sintered Plates.* Shaped molds are made from sintered plates which are rolled during the warm state and welded on the edges.

(5202) Canadian 440,231 (1943). Callite Tungsten Corp., *Seamless Tubes of Refractory Metal.* Mo or W is pressed at 10-20 tsi around a core of borosilicate glass and sintered; a metal rod is then inserted and the compact hot swaged, and drawn.

(5203) Brit. Appl. 12598/47 (1947). Metallizing Engineering Co., Inc., *Extrusion of Composite Wires for Spraying.* A mixture of 7 parts of 80 mesh chromium powder and 1.5 parts of polystyrene powder is passed through a screw type extrusion press and drawn through a wire forming die.

v. Printing Types, Cylinders, Plates, etc.

(5204) U. S. 99,806 (1870). J. A. Adams, *Electrotype Plates.* The plates are quickly formed by coating the impression of wax and type with powdered Sn.

(5205) U. S. 608,248 (1898). L. Boudreaux, *Printing Block.* Wax-impression printing blocks are given a metallized surface by rubbing with bronze powder right after casting.

(5206) U. S. 1,210,375 (1916). A. F. Decker, *Printer's Blanket.* The blanket is coated with an adhesive and a metal powder such as bronze, Pb or Al.

(5207) U. S. 1,971,306 (1934). L. C. Antrim (Autographic Register Co.), *Transfer Device.* A manifolding device of a fabric impregnated with ink has on its ink-transferring side a coating of metal powders for retarding the transference of the ink to a medium pressed into contact with the fabric.

(5208) U. S. 2,199,265 (1940). C. N. Lohrey (National Cash Register Co.), *Porous Printing Type.* The type consists of 70% Ni powder and 30% Cu powder molded under great pressure.

(5209) U. S. 2,346,939 (1944). J. J. Ormond, *Printing Rolls.* Printing rolls are etched by coating with a printing ink, which is highly absorptive of metal powders, and sprinkling a tacky ink image with aluminum or bronze powder.

(5210) U. S. 2,349,613 (1944). R. G. Chollar (National Cash Register Co.), *Printing Plate.* A porous resiliant printing plate has a filler of metal powder.

(5211) U. S. 2,350,564 (1944). H. Menihan (American Bank Note Co.), *Printed Matter.* The matter is composed of ink carrying metal powders compressed into ornamental design with some of the ink incorporated in the metal powder before being compressed.

(5212) U. S. 2,361,665 (1944). W. C. Toland and E. Bassist, *Printing Plates.* The plates have a coating containing filler particles, such as Cu or Zn powders.

(5213) U. S. 2,373,087 (1945). H. C. Alger, *Intaglio Printing Cylinder.* The recesses in the Cu cylinder are filled with wax; the unrecessed portions are plated with Cr, the wax is then removed and the recesses are filled with Cu powder.

(5214) U. S. 2,392,521 (1946). R. G. Chollar (National Cash Register Co.), *Printing Plate.* Powdered metals are used as filters in a porous rubber printing plate.

(5215) Brit. 604,062 (1948). Sintered Products Ltd., C. E. Sinclair and J. W. Lennox, *Printing Equipment.* Improved control of ink flow in duplicating machines is claimed if ink is supplied through a porous metal roll or plate.

vi. Miscellaneous Molded and Sintered Products

(5216) U. S. 1,286,089 (1918). C. A. Pfanstiehl, *Producing Hollow Objects.* Hollow objects are produced by depositing metal powder around a metal part and thereafter removing the metal part with acids.

(5217) German 586,621 (1933). F. Skaupy, *Metal Bodies.* A suspension of metal powder is sprayed on a core, dried, sintered and the core is removed.

(5218) U. S. 2,169,280; 2,169,281 (1939). C.A. Pfanstiehl (Pfanstiehl Chemical Co.), *Shaped Small Objects.* Small shaped objects such as pen points and phonograph needles are formed by sifting metal powder into a minute cavity in a rubber body and applying pressure.

(5219) U. S. 2,169,966 (1939). C. A. Pfanstiehl (Pfanstiehl Chemical Co.), *Metallic Tip.* A metallic tip having no dimension more than 1/8", *e.g.* pen nibs or needles, for small bases is produced by compressing metal powders in a small cavity of an incompressible plastic body.

(5220) German 695,382 (1940). I. G. Farbenindustrie A. G., *Bodies from Powdered Silicon.* Bodies are formed from powdered Si with a binding agent of a metalloid of the 5th or 6th group of the periodical system, to which 10% acid is added.

(5221) German 707,897 (1941). I. G. Farbenindustrie A. G., *Formed Bodies of Silicon.* Improvement of 695,382 (No. 5220). Organic colloids, reversible inorganic colloids, or a solution of caoutchouc as bonding agent is used.

(5222) German 707,898 (1941). I. G. Farbenindustrie A. G., *Molded Bodies Containing Elemental Silicon.* Ground Si or its alloys are pressure-molded without using a bonding material. The molded bodies are then fired without pressure.

(5223) German 711,650 (1941). M. Hauser, *Molded Objects From Silicon or its Alloys.* A molding box consists of Si in the amorphous state mixed with small quantities of Al silicate (of the montmorillonite type, especially bentonite) in the colloidal state as a binding agent, and other clay-type binders as optional additions; the mixture is molded and then fired.

(5224) U. S. 2,377,678 (1945). J. F. Ebert (Smaller War Plants Corp.), *Die.* A die is formed by pressing a charge of metal powders to form a shell for a lock nut.

(5225) U. S. 2,394,394 (1946). R. J. Miller, *Pattern Having Integral Forming Members.* A mold used for molding plastics is produced from sintered metal powders, has venting means, and is formed from a plurality of die patterns, positioned in a flask.

(5226) U. S. 2,413,512 (1946). L. H. Morin and D. Marinsky, *Process of Producing Dies from Powder Metallurgy.* A method of producing duplicate dies employed for forming die cast products, uses a templet die part in forming a

powdered metal die part by sintering whereby the templet is melted.

(5227) U. S. 2,486,435 (1949). W. I. Jones (C. D. Patents Ltd.), *Manufacture of Molded Articles from Coal.* Improved mechanical properties of the molded articles may be obtained by use of fillers, such as Al or Cu bronze powders.

B. Products and Applications for Metallurgical, Chemical and Related Industries

i. Welding Electrodes, Rods and Agents

(5228) U. S. 704,793 (1902). W. Griffith, *Plating Metal.* A Cu plate is welded to a second metal by means of an intermediate coating of powdered Cu.

(5229) German 185,907 (1907). Allgemeine Elektrizitäts Gesellschaft, *Electrode.* An electrode for welding consists of Ag or Ag-plated metals such as Cu.

(5230) U. S. 893,207 (1908). S. A. Tabet, *Welding Copper.* Cu is welded with powdered Cu and borax.

(5231) U. S. 1,539,810 (1925). R. T. Gillette (General Electric Co.), *Welding Electrode.* An intimate mixture of W and Cu is consolidated to form a pressure-resisting composite material capable of operation under high pressure and temperature without deformation.

(5232) Brit. 237,898; 237,901 (1926). The British Thomson-Houston Co. Ltd., *Welding Process.* The welding electrodes may consist of W; H_2 coming into contact with the arc is dissociated into atomic H.

(5233) Brit. 237,902 (1926). R. T. Gillette and British Thomson-Houston Co. Ltd., *Welding Electrode. Cf.:* U. S. 1,539,810 (No. 5231).

(5234) Brit. 353,671 (1931). I. G. Farbenindustrie A. G., *Welding.* Welding is performed with metals such as Fe in powder form obtained by thermal decomposition of metal carbonyls.

(5235) German 526,581 (1931). I. G. Farbenindustrie A. G., *Welding Rod.* The rod is produced by decomposition of metal carbonyls.

(5236) German 547,597 (1932). L. Brandt (Vereinigte Stahlwerke A. G.), *Welding Agent.* A welding agent developing CO consists of a mixture of the carbonyls of such metals as Fe, Ni, Co, U, V, Cr, etc.

(5237) U. S. 1,848,437 (1932). J. A. Weiger and G. N. Sieger (P. R. Mallory & Co. Inc.), *Hard Alloy For Welding Electrodes.* The alloy consists of 72% Cr, Mo, or W, 27.5% Al, Zn, Sb, or Sn and a hardening agent like C or P.

(5238) U. S. 1,876,846 (1932). L. Brandt (Vereinigte Stahlwerke A. G.), *Welding Agent. Cf.:* German 547,597 (No. 5236).

(5239) French 759,367 (1933). C. Hardy, *Welding Rod. Cf.:* Canadian 357,942 (No. 5251).

(5240) German 580,398 (1933). I. G. Farbenindustrie A. G., *Welding Rod.* W, Mo, Ti, Cr, or their compounds, such as H_2MO_4 or H_2CrO_4 are mixed with powdered H_2SiO_3 or H_3BO_3, which form with the metal oxides easily fluidized slags, and are then sintered.

(5241) Japan. 101,747 (1933). K. K. Mitsubishi Zosen, I. Kiyoshi and S. Shintard, *Welding Rod of Iron Powder.* A rod is made by covering an ordinary welding rod with a mixture of powdered electrolytic Fe, starch, $CaCO_3$, SiO_2, or H_3BO_3.

(5242) U. S. 1,918,212 (1933). R. Palmer (General Electric Co.), *Hard Metal Compositions for Pressure-Welding Electrodes.* Pulverized WC is mixed with an organic binder and sintered; the spongy carbide is impregnated with Cu.

(5243) U. S. 1,943,541 (1934). G. Vennerholm and R. H. McCarroll (Ford Motor Co.), *Method of Reclaiming and Reusing Metallic Scrap Mixtures for Welding Electrodes.* Scrap pieces of welding electrodes composed of sintered W particles impregnated with Cu are reclaimed by comminuting to powder, reducing in H_2 at 1000° C. (1830° F.), pressing into electrodes and sintering.

(5244) U. S. 1,952,842 (1934). J. H. Doss (Revere Copper and Brass Inc.), *Welding Rod Alloys.* The alloys consist of Cu, Fe and Ni and Zn in approximately the following ranges: Cu, 42-64.5%; Fe, 0.25-3%; Ni, 0.25-5%; balance Zn. In all instances the sum of Cu, Ni, Fe is from 50-65%.

(5245) U. S. 1,972,463 (1934). L. Schlecht, W. Schubardt and F. Duftschmid (I. G. Farbenindustrie), *Welding Electrode.* 100 parts of Fe powder containing 1.22% C and 1.8% O, are mixed with 1.2 parts of ferro-Mn containing 75% Fe, 0.15% fluorspar, 0.25% $CaSiO_3$; the mixture is sintered at 1200° C. (2190° F.), and the sintered rod is rolled and drawn.

(5246) Brit. 430,327 (1935). C. Hardy and High Speed Steel Alloys Ltd., *Welding Rod Alloy.* Powdered material from Cu, Ni, Zn, Sn is rendered coherent by the application of high pressure and then sintered.

(5247) U. S. 1,999,888 (1935). E. Ammann (Fried. Krupp A. G.), *Welding Rod.* A welding rod is made of an Fe tube filled with a sintered mixture of Cr_3C_2, Si and Mn.

(5248) U. S. 2,002,198 (1935). W. A. Wissler (Haynes Stellite Co.), *Welding Rod.* The rod comprises an aggregate of hard metal particles, having a high temperature of fusion, mixed with a binder, *e.g.* Stellite and an alloy of the hard metal, *e.g.* Hastellite bonded on the outer surfaces of the particles.

(5249) U. S. 2,002,462 (1935). G. W. Woods (Haynes Stellite Co.), *Welding Rod.* A welding rod is composed of an aggregate of small particles of WC with Fe binder, whereby the carbide and the Fe are alloyed together along the outer surfaces of the particles.

(5250) U. S. 2,009,240 (1935). A. T. Roberts and J. H. Paterson (American Murex Corp.), *Welding Rods.* An arc welding electrode consists of a metal core rod or wire provided with a protective coating, containing as a major constituent, powdered metal of substantially the same composition as the core metal.

(5251) Canadian 357,942 (1936). Electro Metallurgical Co. and C. Hardy, *Welding Rod.* A welding rod consists of a coherent aggregate containing 40% Cu comprising compressed and sintered dendritic comminuted Cu with a flux and binder.

(5252) German 625,826 (1936). Deutsche Edelstahlwerke A. G., *Sintered Bars for Production of Welding Rods.* During cooling, the sintered bar is brought into contact with easy oxidizable material which diffuses into the bar.

(5253) U. S. 2,121,194 (1938). C. Hardy (Linde Air Products Co.), *Welding Rod.* Welding rods are produced of a coherent aggregate of finely divided materials including Cu powder.

(5254) U. S. 2,131,475 (1938). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Welding Electrode.* A pressure-exerting welding electrode is made by briquetting a mixture of 99% Cu and the remainder Co and Be.

(5255) German 670,239 (1939). Deutsche Edelstahlwerke A. G., *Welding Rod.* The rod consists of 50-60% W, 2-6% C, 2-6% Ti, 5-15% Cr, and 25-40% Fe.

(5256) German 677,568 (1939). Allgemeine Elektrizitäts Gesellschaft and R. Schulz, *Welding Powder for Aluminum.* The powder consists of 5% Al, 7-10% Sn, 12-15% Cd, 0.8-2% P, with the remainder Zn.

(5257) U. S. 2,160,659 (1939). F. R. Hensel (P. R. Mallory & Co. Inc.), *High-Resistance Electrode.* An electrode suitable for resistance welding is formed of a sintered mixture of refractory metal, *e.g.* W, Mo or Cr, with a refractory metal compound selected from carbides, nitrides, or borides of metals of the 4th and 5th groups of the periodic system and carbides of W and Mo. The mixture is bonded with a Cu-alloy of high electric resistivity. The finished product is characterized by high hardness and mechanical strength at room and elevated temperatures.

(5258) U. S. 2,165,022 (1939). W. C. Anderson, *Welding Rod.* A sintered electrode is composed of Fe material and contains not over 3.5% by weight of C, 2.0% Mo, 0.70% Mn, 0.30% P, 0.10% S, and 2.0% Ni, and is coated by immersion in an Al bath.

(5259) U. S. 2,175,899 (1939). J. M. Kelly (Westinghouse Electric & Mfg. Co.), *Process for Making of Metal Articles.* Welding electrodes are produced by placing in a mold of refractory material a mixture containing a major proportion of highly conductive metal powder on top of a mixture containing a major proportion of refractory metal powder, and heating the powder in a protective atmosphere at a temperature above the melting point of the conductive metal, in the mold while under pressure to produce a dense, composite electrode having a contact tip of refractory metal and a shank of highly conductive metal.

(5260) U. S. 2,204,412 (1940). J. Hinnüber (General Electric Co.), *Weld Rod.* A welding rod consists of a hard sintered alloy in which presintered hard metal particles consisting of one or more cemented carbides are uniformly distributed.

(5261) U. S. 2,266,422 (1941). F. R. Hensel and E. I. Larsen (P. R. Mallory & Co. Inc.), *Welding Electrode.* The electrode is produced by pressing and sintering Cu powder.

(5262) U. S. 2,291,482 (1942). W. C. McLott, *Welding Rod.* A rod of steel is provided with 20% of its weight of a coating containing ferro-Cr, ferro-Mn and graphite powder cemented together around the rod.

(5263) U. S. 2,301,320 (1942). C. E. Phillips and H. R. Pennington (C. R. Phillips & Co.), *Welding Electrode.* A welding electrode has a Ni core, a surrounding coating of Cu and an outer flux coating of metal powder.

(5264) U. S. 2,303,746 (1942). T. E. Kihlgren and R. F. Vines (International Nickel Co.), *Welding Rod.* A coating for Ni arc welding rods comprises Ca and Na-fluorides, Ni-Ti alloy, C and dextrine.

(5265) U. S. 2,326,865 (1943). H. E. Kennedy (Linde Air Products Co.), *Electric Welding.* An electric welding composition contains powdered Fe, steel filings, Al and Cu.

(5266) Swiss 231,936 (1944). Aluminium Industrie A. G., *Arc-Welding Electrode for Light Metals.* The electrode consists of a core of Al or Al alloys coated with a non-hygroscopic light metal flux and a water absorbing material, *e.g.* Al powder plus a silicate; the coating is baked on.

(5267) U. S. 2,355,627 (1944). C. A. Cadwell (Electric Railway Improvement Co.), *Welding Material.* Welding material for use in an exothermic reaction comprises a mixture of Al powder, CuO and combined O.

(5268) Brit. 573,336, 573,337; 573,338 (1945). Murex Welding Processes Ltd. and E. J. Clarke, *Welding Rods.* 30% Cr, 2% Mo, 15% W, 35% Co, 15% Fe, 3% C and Na_2SiO_3 as binder are mixed and extruded into a mild steel sheath which is heated to sinter the powder. Alternately, a wire is coated with the powder or the powder is molded with a thermoplastic resinous component.

(5269) Brit. 573,595 (1945). Murex Welding Processes Ltd. and E. J. Clarke, *Welding Rods.* Fe welding rods for alloy steels are produced by sintering a mixture of metal powders containing a hydride of Cr, Al, Ti or V. During sintering or welding, the metal is generated in powder form and is highly active, owing to absence of oxide films.

(5270) Brit. 573,598 (1945). Murex Welding Processes Ltd. and E. J. Clarke, *Welding Rods.* The rods are formed from a sintered mass containing WC, a small amount of other hard metal carbides and a flux consisting of fluorspar and $CaCO_3$.

(5271) U. S. 2,370,100 (1945). A. B. White (Westinghouse Electric & Mfg. Co.), *Arc-Welding Electrode.* An arc tip on an arc welding electrode is made of Fe_2O_3 and Al powder.

(5272) Brit. 574,550 (1946). Murex Welding Processes Ltd. and E. J. Clarke, *Welding Rods.* Mixed metal powders of compositions desired in the welding rod are sintered into a billet and shaped by rolling, swaging or drawing to required form. A typical composition is 18-20% Cr, 8-10% Ni, 3-5% Mo, up to 5% TiO_2, balance Fe.

(5273) Brit. 578,446 (1946). W. Andrews and Murex Welding Processes, Ltd., *Welding Rod.* A flux-coating may contain a metal powder, *e.g.*, Cr, Ni-Cr, Fe-Mo, or Fe-Ti.

(5274) U. S. S. R. 65,865 (1946). F. A. Tikhii, *Welding Powder.* A powder composed of borax and Fe filings is used for forge-welding steel.

(5275) U. S. 2,421,184 (1947). A. M. Candy (Hollup Corp.), *Apparatus for Electric Welding of Studs.* The arc initiating material, *e.g.*, Al and Fe filings, plus a binder, is pressed to form a disk of predetermined thickness; the disk is retained within the ferrule and against the plate.

(5276) U. S. 2,429,175 (1947). P. C. van der Willigen, J. J. Kreupeling, and J. J. de Jong (Hartford National Bank & Trust Co.), *Coated Welding Rod.* A welding rod for electrical arc welding consists of a core of welding material surrounded by an electrically conductive coating containing 78% finely divided welding metal, *e.g.* Fe, and a second coating of slag forming material.

(5277) Brit. 600,482 (1948). S. A. Des Ateliers Secheron, *Coated Electrodes for Electric Welding.* The exposed ends of the electrodes are either sprayed with powdered steel, Al or Mg, or dipped into a suspension of Fe powder in water glass.

(5278) Indian 34,763 (1948). Tata Iron & Steel Ltd., *Coated Welding Electrodes.* The slag forming coating consists of Fe-oxides, Mn-oxides, and of titanates, formed with Na-silicate into a paste; the metal rod must have a low C content.

(5279) U. S. 2,436,205 (1948). L. R. Deitz and I. W. Johnson (General Electric Co.), *Welding Electrode.* A pressure exerting, resistance welding electrode, used for welding carbonized Ni, has working tips of Cu (200-300 mesh) and 0.25-0.75% graphite powder; the powders are ball milled for 4-6 hours, then pressed in a steel mold and heated in H_2 at 950° C. (1740° F.).

(5280) U. S. 2,436,884 (1948). J. D. Fast (Hartford National Bank & Trust Co.), *Coated Welding Rod.* Arc extinction during welding is prevented by an electrode with a core of not less than 50% Fe and a slag forming coating containing a reducing material other than Mg to prevent oxidation of Fe, and 0.5-5.0% of an arc-preserving agent, containing 90% Mg.

(5281) U. S. 2,441,176 (1948). E. F. Wilson, J. C. Grubb and F. A. Fowler (Babcock & Wilcox Co.), *Metal Linings of Welding Groove in Butt Welding.* A welding groove made from a graphite-coated ceramic body is sprinkled with metal powder, such as pure Fe, along the groove, where powder is melted upon application of welding heat, to provide a pool as barrier to slag entrapment.

(5282) U. S. 2,444,654 (1948). T. E. Kihlgren (International Nickel Co.), *Nickel Electrode for Welding Cast Iron.* The electrode consists of a core wire containing 99.5% Ni, having a flux coating containing 10-30% C and 2.5% Ti in form of an alloy, 30% Fe powder, and a slag-forming material with binder.

(5283) Brit. 616,284 (1949). Welding Supplies Ltd., *Surface Welding.* Hard facing and welding is carried out with an electrode having a core of mild steel coated with a mixture containing 10-30% ferro-Cr, 5-13% ferro-Si, 0-10% ferro-Mn, 18-40% limestone, 27-40% rutile, and 5-16% fluorspar.

(5284) Brit. 618,304 (1949). Welding Supplies Ltd., *Coated Electrodes for Arc Welding.* Welding rod coatings may contain 5-20%, and preferably 10% Fe powder.

(5285) Brit. 619,763 (1949). Murex Welding Processes Ltd. and E. C. Rollason, *Manufacture of Flux-Coated Welding Electrodes.* To prevent undesirable reactions, the Mn powder used in the flux mixture contains 7% Cr, or 10% Al.

(5286) Brit. 621,936 (1949). The Mond Nickel Co. Ltd., *Arc-Welding Electrodes.* The electrodes are coated with a glass-bonded mixture of 32% $CaCO_3$, 29% CaF_2, 15% Fe powder, 15% graphite, 5% ferri-Ti, and 4% bentonite.

(5287) U. S. 2,460,537 (1949). E. C. Rollason (Metal & Thermit Corp.), *Coated Weld Rod.* A welding electrode is provided with a flux-coating whose ingredients comprise an alkali metal compound and an Mn-Al alloy having a composition of 50-98% Mn, 1-10% Al, not over 1.5% C, 5% Si, 5% Cu, and Fe with traces of normal impurities as remainder.

(5288) U. S. 2,461,180 (1949). E. C. Rollason (Metal & Thermit Corp.), *Coated Weld Rod.* In a flux-coated welding electrode the flux ingredients comprise an

alkali metal compound and an Mn-Cr alloy; the alloy is pulverized and the resultant powder is sufficiently stable to alkali compounds so that it may be used in the manufacture of flux-coated welding electrodes of the above type.

(5289) U. S. 2,463,096 (1949). F. E. Garriott (Ampco Metal, Inc.), *Welding Electrode.* A bronze electrode for metallic arc welding and deposition consists of a bronze core rod and a covering which comprises a mixture of fluoride slag-producing materials, a silicate binder, $BaCO_3$, Fe and K. The Fe is in the form of powdered Fe and Fe_2O_3 and the K is in the form of feldspar and K-silicate.

(5290) U. S. 2,464,836 (1949). R. D. Thomas, Jr. (National Lead Co.), *Welding.* A core rod is provided with an electrode coating of Ti-bearing finely divided alloy material having maximum Ti recovery in the weld.

(5291) U. S. 2,468,372 (1949). G. G. Landis (The Lincoln Electric Co.), *Flux Element for Use in Arc Welding.* Powdered Ni and Cr may be used as alloying ingredients in an arc welding process without being attached to the main flux element.

(5292) U. S. 2,471,803 (1949). R. D. Wasserman, *Weld-Rod Flux Coating.* A flux coating composition includes graphite, $BaCO_3$, Si metal powder, MnO_2, and powdered ferro-Cr alloy, ferro-Si alloy and a deoxidizing alloy. A second mixture added to the first, is made of 2-ethyl hexanol, aerosol, and Na silicate of 30 degrees Baumé.

(5293) U. S. 2,471,931 (1949). R. Castro (Soc. d'Électro-Chimie, d'Électro-Métallurgie et des Aciéries Électriques d'Ugine, *Welding Electrode.* Al filings are used in preparing the welding rod.

(5294) U. S. 2,474,787 (1949). G. G. Landis (The Lincoln Electric Co.), *Arc Welding Composition and Method of Making Same.* A flux composition is obtained by intermixing selected known flux ingredients in finely comminuted form, *e.g.*, powdered Al, together with Na- and/or K-silicate.

(5295) U. S. 2,491,593 (1949). P. C. van der Willigen (Hartford National Bank & Trust Co.), *Coated Welding Rod for Electric Arc Welding.* The rod has an Fe core which is provided with a coating, a ferroalloy, containing organic material, TiO_2, $CaCO_3$ and Fe powder as main constituents.

ii. Brazes, Solders and Sealing Media

(5296) U. S. 451,261 (1891). S. V. Buckman, *Tinning of Sheet Metal.* Before tinning, metal sheets are united by coating the edges to be joined with a paste containing metal powder.

(5297) U. S. 1,340,655 (1920). T. E. Henderson, *Repairing Radiators.* A composition used for repairing and sealing radiators of internal combustion engines comprises two kinds of metal powder and a binder.

(5298) Austrian 131,116 (1933). I. Kreidl, *Production of Enamel.* Included in enamel compositions are powders of metals, metal alloys or metalloids which produce H during sintering by reaction with the ingredients of enamel to act as bonding agents.

(5299) French 754,941 (1933). Haynes Stellite Co., *Hard Facing Solder. Cf.:* U. S. 1,977,128 (No. 5302).

(5300) French 759,367 (1934). C. Hardy, *Soldering Pin.* The solder is produced from a powdered mixture of 38% Cu, 53% $Cu_3(PO_4)_2$, 8% Sn, 1% borax, and is pressed in H_2 at 235° C. (455°F.).

(5301) U. S. 1,947,938 (1934). H. Hey, *Soldering Paste.* The paste is made by precipitating on Sn a porous spongy body of Zn and mixing the sponge with a vehicle.

(5302) U. S. 1,977,128 (1934). F. P. Hawkins (Haynes Stellite Co.), *Hard Facing Solder.* A flux of 20% semi-steel chips, 60% Mn, 10% ferro-Si, 5% borax, and 5% burned lime is used to bond WC to steel.

(5303) U. S. 1,980,927 (1934). A. L. Parker, *Solder.* A solder bonding product, comprising a sintered structure of solder particles with a flux uniformly distributed through the pores of the mass, is manufactured by hot pressing or pressing and extruding a mixture of comminuted solder particles and flux, or by forming a porous structure of Ag solder and impregnating with a flux, *e.g.* borax.

(5304) Brit. 436,401 (1935). F. P. Gordon, *Compounded Body Employing Binder of a Manganese Alloy.* A process for the manufacture of composite metal bodies comprises uniting the surfaces with Mn-containing bonding material, employed in granulated or powdered form, with the application of heat and pressure.

(5305) German 613,878 (1935). N. V. Molybdenum Co., *Solder.* The solder contains up to 80% W, Mo, Ta, Ti, or V, which does not melt at the soldering temperature.

(5306) U. S. S. R. 43,738 (1935). G. A. Meerson and R. L. Velles, *Composition for Brazing Working Surface to Tools.* A mixture of oxides of at least two of the metals of Mo, Ti, W, V, Cr, Cb, Ta, and Mn, and C is subjected to aluminothermaic reduction, powdered, mixed with an organic binder and C to form carbides in the brazing process.

(5307) U. S. 2,061,994 (1936). J. O. Betterton and Y. E. Lebedeff (American Smelting & Refining Co.), *Process for Refining Alloys of Lead and Tin.* A process for refining impure solder comprises incorporating a powdered Zn-Mg alloy into the Pb-Sn alloy bath to separate impurities.

(5308) U. S. 2,061,995 (1936). J. O. Betterton and Y. E. Lebedeff (American Smelting & Refining Co.), *Process for Refining Alloys of Lead and Tin.* Impure solder is refined by the incorporation of a powdered Ca-Zn alloy to remove Sb.

(5309) U. S. 2,084,928 (1937). H. Turner (Johnson, Matthey & Co. Ltd.), *Silver Solder.* Ag solder having a solidus below the melting point of the Cu-Ag eutectic (778° C.; 1430° F.) consists of 15-70% Ag, 5-20% Mn, and 20-65% Cu.

(5310) U. S. 2,116,891 (1938). A. Hanak, *Production of Solder.* Scrap Babbitt, hard metals and/or antifriction metals are converted into a solder.

(5311) German 684,612 (1940). Siemens & Halske A. G., *Brazing Copper with Tip of Porous Metal.* The porous tip is made from Ni powder wetted with alcohol, deposited on the support, and sintered; the uncovered part of the heat conducting support has a coating of Ag.

(5312) U. S. 2,189,640 (1940). A. R. Powell (Johnson, Matthey & Co. Ltd.), *Production of Hard Solders.* A mixture of $AgNO_3$ and $Cu(NO_3)_2$ is dissolved in water and mixed with $Ca(NO_3)_2$ or $Mg(NO_3)_2$; the solution is poured into a boiling solution of Na_2CO_3 or NaOH to precipitate the carbonates or hydroxides of Ag or Cu.

(5313) German 703,926 (1941). Siemens Apparate A. G., *Sealing Sparking Plugs.* Ag or Cu powder is incorporated in a sealing cement used for sealing off the electrodes.

(5314) German 705,120; 705,122 (1941). Siemens & Halske A. G., *Brazing Copper with Tip of Porous Metal.* Addition to German 684,612 (No. 5311). Between the support and the tip are provided one or two layers impermeable to air and resistant against the Pb-Sn solder.

(5315) German 705,121 (1941). Siemens & Halske A. G., *Brazing Copper with Tip of Porous Metal.* Addition to German 684,612 (No. 5311). The bit consists of artificially produced Al_2O_3.

(5316) U. S. 2,297,554 (1942). C. Hardy and R. L. Patterson (Hardy Metallurgical Co.), *Method of Brazing or Welding.* A method of brazing or welding employs a bonding element of a porous but coherent mass of Cu powder containing P.

(5317) U. S. 2,301,513 (1942). H. Brewer, *Repairing Cracked Machine Parts.* Cracked cast Fe parts are repaired by pouring HNO_3 into the crack, then applying cast Fe powder and HCl.

(5318) German 736,133 (1943). Siemens & Halske A. G., *Vacuum-Tight Connection Between Bodies of Ceramic and Sintered Metal.* Silicates are mixed into the metal powder or interposed with the ceramic body, which causes a light oxidizing effect on the metal powder during heating and sintering.

(5319) U. S. 2,324,729 (1943). R. H. Schrohe and R. W. Mannel (Crane Co.), *Sealing Compound.* A non-hardening lubricating pipe joint cement comprises a mixture of castor oil, powdered $BaSO_4$ and flake Al.

(5320) U. S. 2,334,609 (1943). E. F. M. Cox (National Lead Co.), *Core Solder.* The solder is produced from comminuted solder metal and a fluxing material.

(5321) U. S. 2,342,842 (1944). D. H. Corbin and R. R. Barrington (General Motors Co.), *Sealing Conductors.* Electrical conductors are sealed in insulators by means of a metallic coating applied in a powdered state to the insulator in its unfired condition.

(5322) U. S. 2,347,211 (1944). G. S. Merrill and G. P. Hollingsworth (Minnesota Mining & Mfg. Co.), *Composition of Sealer.* The sealer contains a metallic flake Al pigment.

(5323) German 750,457 (1945). Anonymous, *Brazing of Cemented Carbide Tips.* A brass of a composition of 81% Cu, 1% Ni, 0.6% Ag, balance Zn, is melted with up to 30% Fe and used in powdered form as brazing alloy. After brazing the Fe is found to be uniformly distributed.

(5324) U. S. 2,367,445 (1945). D. H. Stoltenberg, *Sealing Spark Plug.* The center metal electrode is sealed in the bore of a ceramic insulator of a spark plug by compacting metal powders in the space.

(5325) U. S. 2,368,181 (1945). S. Vernet, *Sealing Means.* Cu powder is used as a pressure seal between a thermostatic element and the plunger.

(5326) U. S. 2,377,322 (1945). E. B. Burrell (Jiggers Inc.), *Soldering Device.* Powdered Fe and/or Al is utilized as a heat supplying material.

(5327) U. S. 2,380,579 (1945). C. Cipriani, *Sealing a Spark Plug.* Powdered metal is used for sealing an electrode to a spark plug insulator.

(5328) U. S. 2,385,580 (1945). J. J. Knox (E. I. Du Pont De Nemours & Co.), *Vitrifiable Flux.* Finely divided Ag is used in a metal-to-ceramic bonding composition.

(5329) U. S. 2,387,722 (1945). A. Y. Dodge, *Vaned Element.* Powdered Cu or brass is used as solder between the parts of a vaned element, and fused by heat.

(5330) U. S. 2,390,452 (1945). W. A. Mudge (International Nickel Co.), *Method of Producing Composite Metal Stock.* A steel foundation layer and a cladding layer of Ni-Cr-Fe alloy is firmly bonded by means of Ni flake powder prepared in a kerosene vehicle; the composite is pressed and heated.

(5331) Brit. 580,655 (1946). The British-Thomson-Houston Co. Ltd. and H. Knight and D. F. Welcit, *Hermetically Sealed Spark Gaps.* Electrodes of W, Ni, Mo powder are mixed with an insulating material, *e.g.* Al_2O_3, MgO or SiC. After sintering, the material is pressed at red heat to reduce porosity.

(5332) French 915,618 (1946). S. A. Brown, Boveri & Cie., *Ceramic-to-Metal Seals.* The ceramic is molded from powders, with a high percentage of metal powder; Fe is incorporated in the layers close to the seal.

(5333) U. S. 2,403,109; 2,403,110 (1946). M. A. Miller (Aluminum Co.), *Brazing Mixture.* A powdered brazing mixture of an alkali metal chloride flux and an Al base alloy is used for joining Al.

(5334) Brit. 584,289 (1947). Mallory Metallurgical Products Co., *Metallic Structures for Sealing to Glass.* Lead-in wires or conductors for sealing to glass or ceramic materials are formed of a mixture of 70-90% W and remainder two of the elements Fe, Ni, Co, Mo, and Cu, to adjust the thermal coefficient of expansion to that of glass.

(5335) Brit. 593,256 (1947). Johnson, Matthey & Co. Ltd. and D. A. Davies, *Metallization of Ceramics.* Ceramic or glass parts are prepared for soldering or brazing by firing-on a layer of Co powder in a solution of cellulose nitrate in amyl lactate at 1300-1500° C. (2370-2730° F.).

(5336) Brit. 594,752 (1947). Johnson, Matthey & Co. Ltd. and D. A. Davies, *Metallization of Ceramics.* Improvement of Brit. 593,256 (No. 5335). A mixture of carbonyl Fe and Ni powder with 7½% Cu powder is proposed for metallizing.

(5337) U. S. 2,417,828 (1947). J. F. Joy, *Sealing Medium.* A sealing compound used for a hydro-pneumatic gun mechanism is composed of 45% bronze powder, 54% Neoprene and 30% C black.

(5338) U. S. 2,431,611 (1947). G. Durst (Metals & Controls Corp.), *Composite Metal Solder.* The solder is composed of a powdered alloy of 40-80% Ag, 0-30% Cu, 5-25% Zn, 5-25% Cd, and 0-10% Sn.

(5339) Brit. 599,789 (1948). Callite Tungsten Corp., *Alloys for Glass Sealings.* An alloy for glass-to-metal seals for electric lamps is made from 15% Mo, 1% Cu, 84% Fe powders, pressed at 10 tsi and sintered at 1300° C. (2370° F.) in H_2 for 1 hour. Additions of Mn, B, Ca, Co, Ni are used for controlling oxide formation when sealing the glass.

(5340) Brit. 606,110 (1948). E. F. Guest and H. J. Enthoven & Sons, Ltd., *Cored Solder.* The wall of the tubing is made excessively thin and the metal saved in this manner is added in powder form to the resin core.

(5341) French 945,257 (1948). Soc. D'Études et D'Applications Financières, *Engine Cylinder.* The steel cylinder lining and the outer finned section of Al alloy are brazed together by means of an interposed layer of Fe and Cu powders.

(5342) U. S. 2,445,309 (1948). L. B. Boyd, *Copper Taped Piston.* An Fe piston body with a thin disk of pure Cu is bonded by a flux of 25% MnO_2, 50% borax, and 25% Cu powder.

(5343) Brit. 619,252 (1949). British Insulated Callender's Cables Ltd., J. D. Shaw, and R. L. Davies, *Cored Solders.* A tube of solder metal is extruded and simultaneously filled with a powder of 60% Sn and 40% Pb and a flux; the tubing is then drawn down.

(5344) Brit. 627,576 (1949). Philips Lamps Ltd., *Resistances Provided with Metal Contacts.* Resistances of sintered MgO containing 3% reduced TiO_2 may have brazed connections consisting of a mixture of Cu, Ti and Sn powders applied in a cresol-formaldehyde resin solution.

(5345) Brit. 628,679 (1949). Cie. Générale De Télégraphie Sans Fils, *Joining of Metal Parts.* Vacuum-tight joints are obtained by making use of shrinkage during sintering; *e.g.*, two tubes of Cu and Kovar are joined by inserting the Kovar tube into a tubular Cu powder pressing.

(5346) French 948,530; 948,575 (1949). N. Ansay, *Brazing Powder.* Carbide tips may be brazed to steel shanks by a mixture of brass powder, borax and glass powder. Tips of high-speed steel are brazed by a mixture of Fe powder, borax and $CaSi_2$.

(5347) U. S. 2,462,020 (1949). P. H. Craig, *Method and Means for Sealing Conductors to Glass Envelope Walls.* To make the control electrode and for sealing the junctures at the upper and lower ends of the tube, a metallic skin is formed on the surface of the tube by painting on a mixture of an oil vehicle with a salt of a noble metal, such as Pt, Au or Ag.

(5348) U. S. 2,462,280 (1949). F. E. Payne, *Seal Adapter.* In rotary seals of the type wherein a seal is effected between two relatively rotatable surfaces located in a plane transverse to the axis of rotation, a sealing washer is made of a resin containing a powdered metal alloy of Pb, Sb and Sn.

(5349) U. S. 2,464,988 (1949). F. E. Payne, *Single Convolution Rubber Sealing Element.* A flexible tubular bellows for use as a fluid sealing device for rotary pumps has a fold in the bellows which flexes in a controllable manner; the sealing element is made of a thermo-setting resin having an alloyed powdered metal, such as Sb, Sn and Pb interposed therein.

(5350) U. S. 2,473,886 (1949). F. C. Hull (Westinghouse Electric Corp.), *Brazing Alloy.* An alloy said to be a particularly good substitute for Ag solders contains 40% Cu, 20% Sn and 40% Zn; the alloys can be ground to powder and compacted under pressure without use of a lubricant.

(5351) U. S. 2,482,925 (1949). D. A. Mercer (Moguloid Co. of America), *Method of Repairing Cracked Hollow Metallic Bodies.* The repair of a crack in an automobile engine block between a valve port and a cylinder involves channeling out the exposed side of the crack, depositing sufficient metal in the resulting groove by electric bonding to restore the original surface and sealing the pores in the

deposited metal and the fine crevices around the pins, with a mixture consisting of alkali metal silicates, drying oils, ground flaxseed, and metal powders, *e.g.* Cu, Al, Fe.

(5352) U. S. 2,487,001 (1949). R. S. Taylor, (Servel, Inc.), *Ammonia Refrigerating Apparatus.* Fe containing about 9-15% of P is used in joining and sealing Fe refrigeration apparatus. The Fe-P brazing material is made in the form of a brazing ring by powder metallurgy techniques.

iii. Cutting Implements and Agents

(5353) German 549,781 (1932). Hoesch-Köln Neuessen A. G., *Autogeneous Cutting of Cast Iron.* Fe is heated above its melting point by the combustion of Al powder which is mixed with preheated gas.

(5354) U. S. 2,327,496 (1943). C. J. Burch (Linde Air Products Co.), *Method of Working Minerals.* A method of working minerals comprises progressively melting metal along a selected path and forming a molten slag, quenching and solidifying the slag, mechanically disintegrating the quenched slag by thermally piercing deep, smooth walled holes or slots, and removing the disintegrated slag from the region of disintegration.

(5355) U. S. 2,343,958 (1944). J. J. Crowe (Air Reduction Co. Inc.), *Tips.* Tips for O_2 cutting torches have a molded insert piece containing the diverging jet passages which is formed from metal powder.

(5356) U. S. 2,415,815 (1947). G. M. Deming (Air Reduction Co. Inc.), *Thermo-Chemically Cutting Metal.* Metal powder and O_2 is used for cutting metal with a torch.

(5357) Brit. 606,540 (1948). Linde Air Products Co., *Method of Flame-Cutting or Flame-Desurfacing Metal Bodies.* Stainless steel can be flame-cut with an oxide-reduced Fe powder (50% -300 mesh) using 20-40 ft^3 O_2 per pound powder.

(5358) U. S. 2,436,001 (1948). J. M. Gaines (Linde Air Products Co.), *Process for Thermally Working Minerals.* The process is a continuation of U. S. 2,327,496 (No. 5354) and comprises using an oxy-fuel flame consisting of a stream of a comminuted alloy of a composition of 50-95% Al, 1-15% Fe, 3-45% Mg.

(5359) U. S. 2,436,002 (1948). V. C. Williams (Linde Air Products Co.), *Flux-Forming Fuel for Working Minerals.* A mixture of 10% Al and other comminuted metals, such as Fe, ferro-Mn, or Si-Mn, is used for executing the process of U. S. 2,327,496 (No. 5354) and 2,436,001 (No. 5358).

(5360) U. S. 2,444,899 (1948). E. Meincke and J. M. Elsman (Linde Air Products Co.), *Blowpipe Apparatus for Thermo-Chemically Removing Metal.* Fe powder is used as promotor material in a stream of O_2 which is used on material normally resistant to thermochemical action of a stream of O_2; it is introduced into the O_2 from a number of points spaced equally about the periphery of the O_2 stream, within the discharge passage of the blowpipe nozzle.

(5361) U. S. 2,444,900 (1948). E. Meincke and H. T. Smith (Linde Air Products Co.), *Blowpipe Apparatus for Thermo-Chemically Removing Metals.* Same as U. S. 2,444,899 (No. 5360), except that details of construction differ.

(5362) U. S. 2,451,422 (1948). R. L. Wagner (Linde Air Products Co.), *Thermo-chemical Removal of Metals.* Powdered low-C ferro-Mn and Fe give good results in cutting Ni, Cu, Al or their alloys having only a slight amount of Fe; the metal is removed by the sole action of a stream of O_2 upon a heated portion, as in ordinary flame cutting.

(5363) Brit. 614,923 (1949). Linde Air Products Co., *Flame-Machining Method and Apparatus.* A blow-pipe nozzle used for powder cutting of stainless steel is described.

(5364) Brit. 620,455 (1949). Linde Air Products Co., *Apparatus for Thermo-chemical Scarfing.* A simple nozzle arrangement and support is provided for flame-machining with Fe powder or ferro-Mn powder; the angle of impact of the powder is regulated according to its particle size.

(5365) Brit. 627,032 (1949). Linde Air Products Co., *Flame-Machining Metals.* Powder cutting of 18:8 stainless steel is carried out with a powdered mixture of 90% Fe and 10% Na_2CO_3.

(5366) U. S. 2,465,978 (1949). E. Meincke (Linde Air Products Co.), *Thermochemical Powder-Scarfing Method.* When thermochemically scarfing a billet of stainless steel, an improved surface can be obtained by concurrently directing a preheating oxyacetylene flame and a stream of finely divided powder (comprising particles of exothermically oxidizable metal) through 2.5-6 inches of space before they enter the reaction zone on the metal body.

(5367) U. S. 2,470,999 (1949). E. Meincke (Linde Air Products Co.), *Thermochemical Metal Removal.* The metal powder is entrained in a gas which is directed into the cutting O_2 jet, and blown against the Fe body at the exact locality of the O_2 impingement; powders comprising 80% steel and 20% ferro-Mn are suited for the method.

(5368) U. S. 2,491,440 (1949). W. S. Boedecker (The Bastian Blessing Co.), *Apparatus for Flame-Cutting Metal.* A cutting blowpipe and associated apparatus may be adapted to inject metal powders such as Mg into the flame, or a thermit mixture of Fe_2O_3 and Al.

iv. Metallurgical Starting Materials, Addition Agents, Master Alloys, and Fluxes

(5369) U. S. 1,350,709 (1920). J. H. Deppeler (Metal & Thermit Corp.), *Alloying Tungsten.* An alloy of W is formed by compressing W powder into tablets or bars and adding it to the molten second alloy metal in the furnace.

(5370) German 343,738 (1921). Metal & Thermit Corp., *Production of Tungsten Alloys. Cf.:* U. S. 1,350,709 (No. 5369).

(5371) U. S. 1,555,978 (1925). A. M. Hunt (American Magnesium Corp.), *Metal Stock Addition Metal.* A mechanical mixture of metals in form of compressed coherent masses with dispersed Mg is used as addition agent in the production of metal stock.

(5372) U. S. 1,714,679 (1929). D. C. Lee, *Bearings.* A bearing alloy is produced by adding comminuted brass to molten Babbitt metal.

(5373) U. S. 1,922,037 (1933). C. Hardy (Hardy Metallurgical Co.), *Treatment of Alkali Metals.* An alkaline earth metal is treated with Ca by mixing and briquetting the alkali metal with Ca shavings or powder and congealing the Ca in molten form to yield a mechanical mixture of the metals, whereby the metals are not alloyed with one another.

(5374) French 764,247 (1934). Firth Sterling Steel Co., *Sintered Hard Iron Alloys.* A powdered carbide of W, Cr, Mo, V, Ti, Ta, Zr, Th, U or Cb is used with other components to form a melting charge for making Fe and steel alloys.

(5375) U. S. 1,975,310 (1934). G. J. Comstock (Firth-Sterling Steel Co.), *Process of Making Ferrous Alloys.* A powdered mixture of 10% WC, 25% W, 4% Cr, 1% Va, 20% Co, and 40% Fe is melted and then poured into molds.

(5376) German 618,956 (1935). I. G. Farbenindustrie A. G., *Production of Welding Steel.* The hollow spaces between pieces of fagots of old Fe are filled with metal powders which produce reducing gases during the heating.

(5377) Brit. 461,115 (1937). Charles Hardy Inc., *Refining or Alloying Metals.* Alkali or alkaline-earth metal is introduced in form of powder briquettes into a molten bath of metal to purify or alloy with the metal.

(5378) French 814,174 (1937). Hardy Metallurgical Co., *Manufacture of Alloys.* A porous mass of Ca and Cr is made by stirring into molten Ca an equal weight of Cr powder.

(5379) Brit. 487,939 (1938). Hardy Metallurgical Co., *Manufacture of Alloys.* Finely divided Ca is mixed with ferro-Cr and briquetted; the briquette is submerged

in a bath of molten Fe and kept there until it has been consumed.

(5380) U. S. 2,128,089 (1938). F. R. Hensel and E. I. Larsen (Westinghouse Electric & Mfg. Co.), *Article of Manufacture.* An addition agent to molten metal comprises 1-25% Cr powder, not more than 10% of a deoxidizing material, balance Cu powder; the mixture is subjected to high pressure to compact it.

(5381) U. S. 2,163,224 (1939). P. P. Alexander (Metal Hydrides Inc.), *Method of Producing Alloys.* The production of metal alloys comprises heating metal powders of Cu or Ni with Ti-hydride to a temperature at which the hydride dissociates and then raising the temperature until the Ni or Cu forms a fused alloy with Ti.

(5382) Italian 378,090 (1940). I. G. Farbenindustrie A. G., *Process for the Production of Alloys.* In the production of alloys through fusion, addition agents of alloy components in powder form are exposed to preliminary sintering in the furnace atmosphere prior to fusion.

(5383) U. S. 2,260,226 (1941). J. S. Kirkham (Mechanite Metal Corp.), *Method and Means for Introducing Alloying Material.* Powdered alloying material is introduced into molten metal as it drops from the furnace to the ladle.

(5384) U. S. 2,291,865 (1942). H. Bernstorff and A. Allendörfer (Chemical Marketing Co., Inc.), *Process for the Production of Metal Alloys.* In the production of a metal alloy containing a reactive metal having a great affinity for gases such as Be, Ti, Th or W and a less reactive metal such as Cu, Fe, Mo, or Ni, the mixture of powders is heated to form a preliminary alloy which is employed to introduce the desired quantity of the reactive metal into further quantities of the less reactive metal.

(5385) U. S. 2,300,943; 2,300,944 (1942). A. Linz (Climax Molybdenum Co.), *Process of Alloying Tungsten with Ferrous Metal.* In the alloying of W or Mo with Fe alloys by fusion, powdered Al is added as reducing agent.

(5386) U. S. 2,302,615 (1942). A. Linz (Climax Molybdenum Co.), *Briquettes Suitable for the Use in the Addition of Molybdenum to Ferrous Alloys.* Fe particles are mixed with reduced MoO_3 and highly compressed.

(5387) U. S. 2,302,616 (1942). A. Linz (Climax Molybdenum Co.), *Briquettes Suitable for Use in the Addition of Tungsten to Ferrous Alloys.* Fe particles are mixed with W oxides and highly compressed.

(5388) Brit. 553,427 (1943). Climax Molybdenum Co., *Alloying Tungsten with Molten Ferrous Metal.* To a molten Fe metal is added a mixture of an oxide of W intimately mixed with a C binder and a reducing agent.

(5389) Brit. 553,691 (1943). A. Linz, *Alloying Tungsten with Ferrous Metals.* A mixture of partially reduced WO_3 particles and Fe particles intimately mixed together is added to molten Fe metal, at a temperature to effect absorption of W.

(5390) U. S. 2,307,512 (1943). J. M. Kelly (Westinghouse Electric & Mfg. Co.), *Process of Making Copper Base Alloys.* Cu-base precipitation hardening alloys are produced by adding up to 1% W in powder form as a deoxidizer for the Cupola alloy manufacture, as W is insoluble in Cu in the solid state.

(5391) U. S. 2,329,698 (1943). R. S. Dean (Chicago Development Co.), *Preparation of Manganese Alloys as Addition Agent for Stainless Steel.* An alloy, formed by sintering a compressed mixture of metal powders containing a major proportion of powdered electrolytic Mn of at least 99.9% purity is used as an addition agent in melting and processing stainless steels; diffusion is obtained at lower temperature when Mn replaces Ni.

(5392) Brit. 559,295 (1944). A. V. v. Lipinsky, *Iron and Steel.* Fe or steel is produced from ores by grinding the ore into small granules, heating directly by electric resistance in a tunnel furnace to a temperature of 500-1000°C. (930-1830° F.) and reducing the granules with H_2. The resulting spongy Fe is then separated from the gangue molded into briquettes under high pressure and melted with the usual additions to form refined Fe.

(5393) German 744,239 (1944). I. G. Farbenindustrie A. G., *Iron-Rich Zinc Alloy.* Carbonyl Fe powder is added to molten Zn to maintain fluidity; it is claimed that evaporation of the Zn and oxidation of the Zn and Fe can thus be prevented.

(5394) German 750,355 (1944). Gesellschaft für Elektrometallurgie Dr. H. Gehm, *Vanadium Master Alloy.* A master alloy for adding V to an Fe melt is made by sintering a 2:1 mixture of moistened vanadic acid with 90% ferro-Si at 500° C. (930° F.).

(5395) U. S. 2,339,673 (1944). A. L. Boegehold (General Motors Corp.), *Treatment of Cast Iron.* A heat resistant Fe casting contains C, Si and Mn powder; the elements are added in a small amount to the molten cast Fe.

(5396) U. S. 2,348,849 (1944). L. Reygagne, *Cast Iron.* Cast Fe, containing more than 3% C and Si is refined by pouring molten cast Fe into the bottom of a ladle containing Fe scrap and hammer scale and stirring.

(5397) U. S. 2,353,657 (1944). W. G. Edwards and E. L. McCandless (Linde Air Products Co.), *Treatment of Castings.* To reduce shrinkage cavities castings are treated with O_2 and particles of combustible metal.

(5398) U. S. 2,370,608 (1945). M. J. Udy, *Powder Addition in Metallurgy of Ferroalloys.* Finely divided low-C ferro-Cr is used as an addition agent in alloying molten Fe or steel.

(5399) U. S. 2,370,610 (1945). P. Adeline (Thermoloys Ltd.), *Manufacture of Ferromanganese.* C-free ferro-Mn is produced by mixing particles of Mn-Fe ores with scrap Al particles in the presence of fluxes and igniting.

(5400) U. S. 2,375,291 (1945). E. F. Doom (Electro Metallurgical Co.), *Production of Alloy Steel.* Comminuted Cr alloy is added to a molten steel bath.

(5401) U. S. 2,429,285 (1947). F. A. Woolley (Midland Motor Cylinder Co. Ltd.), *Cupola Furnace for Melting Powdered Metals.* The powdered metal is charged on a bed of solid fuel, ignited, and air is introduced; the products of incomplete combustion are swept beneath the metal, conducted to the upper part of the furnace, and there mixed with air to form a hot upper zone above the metal.

(5402) Brit. 605,686 (1948). H. O. Ross, *Composite Mineral and Metallic Products.* FeS_2 is mixed in equal quantities with one of the metals Al, Cu, Mg or Fe and pressed without sintering.

(5403) Brit. 606,593 (1948). British Cast Iron Research Assoc., H. Morrogh and J. Bernstein, *Manufacture of Iron Castings.* Uniformly mottled Fe castings are made by adding, immediately before pouring, briquettes of ferro-Si and B_4C bonded with Na-silicate.

(5404) French 936,336 (1948). N. V. Philips' Gloeilampenfabrieken, *Manufacture of Austenitic Manganese Steels.* The wear resistance of Mn steel parts is increased by adding to a melt of 12% Mn, 1.2% C, balance Fe, a mixture of finely divided V and C, to form VC in the steel.

(5405) Italian 423,207 (1948). U. Calistri and Z. Pensa, *Copper Extraction from Alloys.* By stirring Al powder into a molten alloy of 15% Cu, 20% Sn, 15% Sb and 50% Pb, a slag is formed containing 50% Cu; no Cu remains in the alloy.

(5406) U. S. 2,438,221 (1948). J. Kurtz and E. Zampieri (Callite Tungsten Corp.), *Method of Making Hard Metal Facing Alloy with the Aid of a Prealloy.* A hard facing alloy is produced by first making a prealloy, by pressing into pellets and sintering a mixture of 95% WC and 5% Fe_3C powder, then preparing a melt of Cr and Co and fusing with the W-Fe-carbide pellets, adding deoxidizing material and casting into ingots.

(5407) Austrian 163,890 (1949). A. Wegscheider, *Production of Prealloys for Transformer Sheets.* A metal powder mixture, containing 1-30% Al, 4-20% Sn, and balance Fe, is sintered.

(5408) Brit. 611,643 (1949). The New Jersey Zinc Co., *Melting of Zinc Dust.* Zn dust is mingled with a shower of molten Zn particles thrown up mechanically from the bath of molten Zn.

(5409) Brit. 618,560 (1949). A. B. Kanthal, *Heat Resistance Machinable Alloy.* An alloy containing carbides and alloys is obtained by adding the carbides to the melt in powder form, and blowing a controlled amount of O_2 into the melt.

(5410) U. S. 2,461,229 (1949). A. J. Murphy (Magnesium Elektron Ltd.), *Method of Producing Magnesium Base Alloys.* An Ag-Be pre-alloy is added as a flux to

Mg which has been protected from combustion during melting. Such pre-alloys as Ag with Be and Zr can be produced by melting Ag with massive Be and Zr metal powder or Zr hydride powder *in vacuo* in a high-frequency electric furnace.

(5411) U. S. 2,461,697 (1949). A. L. J. Queneau, *Recovery of Zinc from Its Ores.* A method of reducing ZnO comprises mixing 4.3 moles of it with 4.5 moles of C, 2.0 moles of Al powder and a flux containing Ca and Mg. The mixture is briquetted, and the briquettes are delivered to a smelting zone in the presence of a blast of O_2 and N_2.

(5412) U. S. 2,464,767 (1949). L. M. Pidgeon and S. A. McCatty (Dominion Magnesium Ltd.), *Production of Calcium.* Pure metallic Ca is produced in coherent metal crowns by a process which includes heating briquettes of a mixture consisting essentially of finely divided metallic Al and finely divided lime material in a retort at about 1170° C. (2180° F.) and in vacuum, and condensing the vapors of Ca; the lime contains not more than 3% impurities and not much more than 1% MgO.

(5413) U. S. 2,465,989 (1949). F. J. Sowa, *Process for Producing Elemental Boron.* An alkali or alkaline earth metal is finely divided by mechanical means and the metal powder is mixed with a fluoborate salt selected from Na, K, Ca, Mg and NH_4 fluoborate. The resulting mixture is fused, impurities are dissolved and elemental B is recovered from the residue.

(5414) U. S. 2,466,091 (1949). A. L. Feild (Armco Steel Corp.), *Alloy Process.* A briquetted N-treating agent comprises ferro-Cr and $Cu(CN)_2$. This is added to a bath of stainless steel to produce a steel of appreciable N content.

(5415) U. S. 2,470,010 (1949). S. D. Williams, *Melting Iron in Electric Furnaces.* A large briquette formed of machine shop turnings, cast Fe borings, mill scale or scarfings, etc. and Fe_2O_3 is used in this method of making low-C steel from steel scrap and molten metal in an electric furnace. Molten direct cupola metal is poured over the briquette and forms the balance of the furnace charge.

(5416) U. S. 2,472,071 (1949). E. Gathmann (Gathmann Research Inc.), *Mold Assembly for Producing Cast Metal Slabs.* A mold is provided for casting an easily friable metal slab, such as a slab of Cr or V. The slab or block ingot can be readily broken into small fragments which in turn are crushed to sizes suitable for use in the alloying of steels. The slab is disk-like in formation and the mold is so constructed that a dendritic crystalline structure results that is easily fragmented.

(5417) U. S. 2,474,538 (1949). C. H. Mahoney and G. L. Lee (U. S. A., represented by the Secretary of the Navy), *Alloying Manganese with Magnesium.* The alloying procedure comprises introducing crushed metallic Mn into essentially Al-free molten Mg at 750-800° C. (1380-1470° F.); the particle size of the Mn is in the range -4 mesh +150 mesh.

(5418) U. S. 2,477,406 (1949). H. Church (The Permanente Metals Corp.), *Charging Magnesium Retorts.* An object is to provide a safe and simple method and apparatus for charging retorts with dry pelleted Mg. The material is maintained under a controlled atmosphere while being charged to the retort bottle by a vertically disposed atmosphere lock which is sealed at its lower end to the neck of the bottle.

(5419) U. S. 2,478,345 (1949). C. L. Vance (Ohio-Ferro Alloys Corp.), *Alloying of Gray Iron in the Cupola.* The process consists of mixing only fragments of ferroalloys (taken from a group consisting of Cr, Si, Mn, Cu, Ni, Mo and P) and about 5% of a binder (tar or pitch) and forming the mixture into highly compressed briquettes. The briquettes are added to the cupola charge and the charge is melted in the cupola to produce alloyed gray Fe.

(5420) U. S. 2,479,097 (1949). N. J. Buchana, *Boron Carbide Compound.* For addition to an Fe-base alloy melt, a mixture consists of powdered B_4C, H_2-reduced Fe and Ni. The quantities of the ingredients range from equal proportions to proportions in which the Fe is not less than half that of the B_4C and the Ni is not less than 20% of the total mixture.

(5421) U. S. 2,481,599 (1949). A. B. Kinzel and C. O. Burgess (Union Carbide and Carbon Corp.), *Alloy Addition Agent.* An agglomerated mixture intended for incorporation into molten Fe or steel is composed of 70% ferro-Cr, 20% MnO_2, 3% $CaSiO_3$, and as a binder 7% Na-silicate.

(5422) U. S. 2,482,423 (1949). V. T. Malcolm (The Chapman Valve Mfg. Co.), *Copper Base Alloy.* Powdered metallic Ti is placed in the bottom of a crucible and covered with a mixture of KNO_3, borax and ground charcoal. Then the crucible is charged with Cu-base metal, covered with a mixture of charcoal and borax, followed by melting in an oxidizing flame and de-oxidizing with a small amount of P. The Ti is approximately 0.10 to 1.25% of the alloy.

(5423) U. S. 2,486,433 (1949). T. S. Perrin and T. S. Seybert (Diamond Alkali Co.), *Production of Flux for Magnesium and Magnesium Alloys.* The flux is prepared by collecting waste from Mg electrolytic cells comprising sludge having 20 to 30% $MgCl_2$, 30% NaCl, 18 to 23% MgO, 6 to 15% Mg, 12 to 17% $CaCl_2$ and smaller amounts of CaF_2, Fe and graphite.

v. Metal Surface Coating, Spraying, Metallizing, Cladding and Molding Compositions

(5424) U. S. 148,795 (1874). E. Wood (J. H. Legge), *Coating Iron and Steel to Prevent Oxidation.* A coating for rolled Fe or steel is composed of pulverized metals, *e.g.*, Pb, Zn, brass, Cu, Mn, Sn and Sb, borax, flake white and lime, and is fused and repowdered.

(5425) U. S. 242,649 (1881). W. H. Howes (Hale & Mulford, Inc.), *Method of Ornamenting the Surface of Jewelry.* To ornament metal buttons, solder filings are sprinkled over a layer of Au or Ag filings and the solder melted to fasten the Au or Ag.

(5426) U. S. 360,283 (1887). W. C. Edge, *Ornamenting Jewelry.* Cu wire is arranged on Au backings in a pattern, then Au or Ag filings are fused together around the Cu wire, which is dissolved.

(5427) U. S. 437,468 (1890). D. Wheeler (Acme Shear Co.), *Finishing Metallic Surfaces.* Handles of scissors are finished by coating them with Au size, applying the metal as powder and baking it.

(5428) U. S. 470,492 (1892). J. Kennedy, *Coating for Iron.* A coating for Fe comprises tobacco juice mixed with metal powders.

(5429) U. S. 546,446 (1894). G. Gross (Plymouth Cycle Mfg. Co.), *Coating of Bicycle Frames.* Bright steel tube bicycle frames are coated with size, baked to give the size tackiness, dusted with Al bronze powder, baked, varnished and baked again.

(5430) U. S. 629,426 (1899). G. D. Coleman, *Coating for Metal Parts.* A coating for metal ship bottoms consists of a layer of paint with a comminuted soft metal, second coating of paint, and a layer of comminuted Cu.

(5431) U. S. 639,537 (1899). W. C. Dickey, *Coating of Iron or Steel.* Sheet Fe and steel are protected by coating with a mixture of powdered Al and PbO, then hammering or rolling.

(5432) U. S. 682,173; 682,174 (1901). G. D. Coleman, *Protective Coating.* A protective coating for chemical holding tanks is applied by first coating with paint, then with comminuted metal or alloy, applying finely divided solder, and heating.

(5433) U. S. 682,914 (1901). G. D. Coleman, *Antifouling Coating.* A coating for metal ship bottoms consists of a layer of paint, a layer of finely divided vegetable insulation with powdered Cu hammered into coatings.

(5434) U. S. 717,080 (1901). G. D. Coleman, *Coating for Metals.* A corrosion- and high temperature-resistant coating for metal consists of an outer layer of powdered metal and an intermediate layer of comminuted soft metal.

(5435) U. S. 741,769 (1903). G. D. Coleman (Coleman Ship Coppering Co.), *Antifouling Coating.* A coating for metal ship bottoms consists of a layer of paint, a layer of ground, oiled, and Pb-coated wood and a layer of Cu powder.

(5436) U. S. 829,386 (1906). S. Cowper-Coles, *Deposition of Metal upon Metallic Articles.* Metal is coated with Sb in powdered form and heated.

(5437) U. S. 886,349 (1908). W. H. Connell, *Manufacture of Railway Rails.* A railway rail is given a track coating of pulverized Ni or Mn which is mechanically worked into the surface.

(5438) U. S. 896,751 (1908). E. Norton, *Composite Coated Steel Sheets.* Steel sheets are coated along the seams with varnish and Al bronze powder.

(5439) U. S. 904,444 (1908). J. W. Paton, *Coating Iron or Steel.* Finely divided metal is mixed with equal or greater quantity of powdered SiO_2 or C which is packed around the article, and the whole is heated.

(5440) U. S. 931,503 (1909). W. G. Scott (Chicago Varnish Co.), *Dipping Process for Coating Articles.* Articles are coated by dipping them into a bronze liquid bath containing bronze powder and blowing air through the bath for uniform coating.

(5441) U. S. 1,029,522 (1912). B. D. Avis, *Coating Aluminum.* For coating Al with Sn a composition of $SnCl_2$, $ZnCl_2$ and powdered Sn is used.

(5442) German 256,925 (1913). M. U. Schoop, *Method of Producing Metal Coatings.* Metal powder is centrifuged against the surface of the body.

(5443) German 280,752 (1914). W. A. Guertler, *Surfacing of Babbitt Metal.* Babbitt metal is coated with Fe by spraying finely divided Fe on the matrix of Pb.

(5444) U. S. 1,128,059 (1915). M. U. Schoop (Metals Coating Corp. of America), *Metallic Coatings.* Coherent metallic coatings are produced by projecting finely divided non-molten metal onto the metal surface by a reducing gas.

(5445) U. S. 1,161,944 (1915). J. H. Maddy and B. H. Schubert (The Lohmann Co.), *Protective Metal Coating.* Powdered Pb is mixed with an Hg salt and fused on frames.

(5446) U. S. 1,236,383 (1917). F. A. Fahrenwald (as represented by The United States of America), *Coating Tungsten.* W or Mo is coated with Au by applying powdered Au or an Au salt in a cleansing flux and heating.

(5447) U. S. 1,380,847 (1921). F. L. Soerenson (Metal Protection Labs.), *Treating Ferrous Articles.* Fe articles are provided with a corrosion resisting coating consisting of a mixture of caustic alkali, water, a metal powder and a metal-oxygen compound.

(5448) U. S. 1,431,395 (1922). H. G. Grinlinton, *Coating of Metals.* For tinning of Cu or brass, powdered Sn is mixed with a carrier, and stearic acid is used for a flux. The mixture is applied to the surface and heated until the Sn melts.

(5449) Brit. 225,072 (1924). H. Connelly, *Coating Composition for Metals.* The coating comprises an intimate mixture of powdered Sn, $CaSO_4$ and dextrin.

(5450) U. S. 1,565,495 (1925). C. W. Pfeil, *Protective Aluminum Coating.* A protective Al coating for Fe is made from powdered Al which is protected from oxide coating by adding oil.

(5451) U. S. 1,565,496 (1925). C. W. Pfeil, *Making Corrosion-Resisting Metals.* Sn-coated Fe metal is heated until the Sn melts; Al powder is applied until its saturation in Sn is reached.

(5452) German 437,502 (1926). V. Planer, *Coating of Wires.* The wire is passed through an emulsion of Sn dust in oil, and is heated after it emerges.

(5453) Brit. 261,017 (1927). E. D. Feldman, *Process of Coating Articles with Metal.* A sticky coating of bituminous substance is first applied and then atomized metal is applied with a Schoop gun.

(5454) German 469,358 (1928). R. Auerbach and W. Steinhorst, *Metal for Coatings by Spraying.* The metal powders are mixed with a binder and formed into wire.

(5455) U. S. 1,662,865 (1928). J. W. Powell, *Coating of Metal Articles.* A decorative coating for metal articles comprises a mixture of lacquer and Au-bronze.

(5456) U. S. 1,705,057 (1929). E. Brandus, *Telephone Cable Armor.* Telephone cable armor comprises a molded mixture of Fe powder and a finely divided Pb alloy.

(5457) U. S. 1,711,603 (1929). E. Lay, *Coating of Metal.* Al alloy powders of great uniformity for coating metals are obtained by adding Al to a powdered clay base in small amounts, igniting it in an inert atmosphere and repeating until the desired percentage of Al is obtained in the powder.

(5458) U. S. 1,729,065 (1929). W. H. Cole, *Material for Protecting Iron and Steel.* Fe or steel articles are coated by revolving them in a cylinder containing emery, Cu-Zn precipitate and Al powder.

(5459) U. S. 1,735,000 (1929). J. G. Dely (Chemical Research & Designing Co.), *Copper Coating.* To facilitate welding together of Cu particles used to coat steel or Fe plates, Cu particles are mixed with NaF.

(5460) Brit. 331,550 (1930). W. Baur, *Coating Metal Bodies.* Metal surfaces are coated with a varnish-like material containing metal powder.

(5461) U. S. 1,758,473 (1930). M. U. Schoop, *Coating Articles with Metal.* Metal coatings are produced by applying a reducing melting flame to a mixture of metal powders and a combustible liquid in a closed chamber.

(5462) U. S. 1,766,417 (1930). W. E. Watkins (Copper Plate Sheet & Tube Co.), *Forming a Film of a Plating Metal.* A film of a plating suspension in finely divided condition is formed on the metal to be plated by heating.

(5463) U. S. 1,804,991 (1931). G. A. Johnson (American Steel Pipe Co. Inc.), *Process for Coating Metal Surfaces.* Metal surfaces are coated by dipping into a bath containing metal powders and a liquid vehicle, including linseed oil, gum, and metal salts.

(5464) U. S. 1,810,409 (1931). W. E. Watkins (Copper Plate Sheet & Tube Co.), *Method of Plating Metals.* A plating alloy of two metals is applied on an Fe base by first plating with Zn, then applying Cu particles in a spreading medium, and heating.

(5465) Brit. 385,496 (1932). Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H., *Coating Thermionic Valve Electrodes.* Powders of W, Mo, or Ta are used for the coating.

(5466) Brit. 402,203 (1933). British Refractories Research Assoc., *Producing a Coating of Oxide.* A powdered element, *e.g.* Al, Si, Ca, Mg, which forms on oxidation refractory oxides, is introduced into the air or the O_2 blast of an oxidizing flame which is directed upon the surface to be coated, to form a refractory coating on a metal base.

(5467) U. S. 1,893,830 (1933). R. P. Turner (New York Wire Cloth Co.), *Wire Fabric.* Wire fabric is produced by coating it with Al powder in a suitable vehicle, such as spar varnish.

(5468) U. S. 1,902,059 (1933). J. H. Critchett (Electro Metallurgical Co.), *Production of Alloy Surface Castings.* Fe-Cr surfaced castings are produced by lining molds with Fe-Cr powder.

(5469) U. S. 1,902,478 (1933). E. Wiegand (General Electric Co.), *Cathode.* A thermionic tube cathode is made by painting Ni in a volatizable vehicle onto porcelain tubing and then sintering the coating.

(5470) U. S. 1,939,667 (1933). H. Csanyi, *Metallic Coating.* A coating for use on a metallic base, *e.g.* Fe, is composed of a mixture of powdered Zn, Pb, Sn and a chloride dispersed in an aqueous solution; it is applied to the base by brushing or spraying and heated to fuse the coating. A typical composition is 45% Pb, 5% Sn, 39% Zn, and 10% $ZnCl_2$.

(5471) U. S. 1,953,508 (1934). O. Schober (American Lurgi Corp.), *Coloring and Protective Coating.* A coating and protective composition consists of a paint vehicle and a pigment of an Al-Si alloy; Si is present to increase corrosion resistance and heat transmission.

(5472) U. S. 1,980,670 (1934). H. A. Eckman and H. W. Maack (Crane Co.), *Inhibitor for Nitriding Process.* The inhibitor or the protective coating is made of 30-40% NH_4 phosphate in solution, 3-10% boric acid solution, 35-90% Sn powder, 5-60% ground SiO_2, 1-25% kaolin.

(5473) U. S. 1,998,506 (1935). W. S. Jones, *Mounting for Precious Metal in Leaf and Powdered Form.* The mounting consists of Al foil with a coating of metal powder and adhesive.

(5474) French 801,004 (1936). Drake, McGee and Hallstedt, Inc., *Coating Metal Surfaces.* A metal base surface, *e.g.* Fe, is coated with another metal, *e.g.*, Al, by applying to the base a mixture of finely divided Al and a volatile solvent, and heating to a temperature between the melting points of the two metals so that part of the Al diffuses into the Fe to form an intermediate layer.

(5475) U. S. 2,048,309 (1936). C. E. Williams, D. E. Krause and C. H. Lorig (The Battelle Memorial Institute), *Mold.* A mold for preparing enameled cast Fe for stoves is coated with Cu powder to produce a blister-free surface for the enamel.

(5476) Brit. 474,245 (1937). Remy, Van Der Zypen & Co., *Device for Metallizing Iron Bands or Wires. Cf.:* German 686,752 (No. 5484).

(5477) U. S. 2,072,229 (1937). L. Waitman, *Tinning Method.* Metal is tinned by dipping a wet sponge into a dry mixture of $SnCl_2$ and a tartrate, and then in pulverized Zn, and rubbing the sponge on the metal surface.

(5478) U. S. 2,078,808 (1937). J. V. Reardon and P. L. Goodale (Reardon Co.), *Metallizing Composition.* A dry powdered base for a metallic coating composition which produces a coating upon solution can be applied to steel and other structures.

(5479) U. S. 2,091,714 (1937). J. C. Matthews (Eastman Kodak Co.), *Metal Finish.* A protective coating for metallic mirrors comprises depolymerized chlorinated rubber containing a filler of metal powders.

(5480) U. S. 2,111,395 (1938). O. J. Hartwick (Pittsburgh Plate Glass Co.), *Coating of Steel Barrels.* A resin film for coating steel barrels contains metal powders as the stabilizing pigment.

(5481) U. S. 2,123,537 (1938). P. G. Marr, *Spraying Powders Such as Zinc or Aluminum on Steelwork.* An apparatus for spraying powders contains, between the main and base chambers, a constricted junction of the form of a Venturi tube.

(5482) U. S. 2,151,312 (1939). G. Ariotti (Atlas Powder Co.), *Hammered Metal Finish.* A hammered metal finish is produced on metal surfaces by applying, by a splattering operation, a coating composition comprising metal powder, a resinous base and a solvent.

(5483) U. S. 2,161,104 (1939). G. S. Smith, *Metallic Coating Suitable for Use on Iron.* A surface is coated by a mixture of Zn dust, As_2O_3, TiO_2 and $CrCl_2$.

(5484) German 686,752 (1940). Remy, Van Der Zypen & Co., *Device for Metallizing Iron Bands.* Fe bands are metallized by applying Al powder on a travelling lacquered Fe band which goes through a closed space; the device is equipped with brush rolls, and tubes through which air and metal dust are sucked out.

(5485) U. S. 2,254,013 (1941). R. Larson, *Hairpin.* A coating for hairpins comprises metal powder suspended in lacquer.

(5486) U. S. 2,262,072 (1941). T. H. Vaughn (Union Carbide and Carbon Research Laboratories), *Metallizing Operation.* Molten metal is sprayed onto an article to be coated, *e.g.* coating steel with bronze.

(5487) Canadian 436,644 (1942). Metallizing Engineering Co., *Process of Surfacing by Spraying Metal Powder.* The surface to be sprayed is roughened with Ni deposited from a wire electrode.

(5488) German 719,586 (1942). O. Kamps and H. Dettmann, *Process for Cladding Magnesium.* Mg or Mg alloys are dusted with Zn powder before cladding with Al to prevent formation of an Mg-Al alloy.

(5489) Swiss 219,342 (1942). M. U. Schoop, *Metal Coating.* The metal is heated in N_2 to produce a nitrided surface before it is sprayed with the metal powder used for coating.

(5490) Swiss 223,550 (1942). Metallisator Berlin A. G., *Spraying Gun.* Wire of a metal used for coating is pressed against the circumference of the friction gear with fixed axis and moves against the nozzle eccentrically to the axis of the nozzle system.

(5491) Swiss 224,135 (1942). M. U. Schoop, *Production of Metal Coatings.* The coating procedure consists of melting metal wires of W, Mo, Ta in the electric arc, and atomizing the melt by pressurized gas.

(5492) Swiss 226,459 (1942). M. U. Schoop, *Metallic Coatings.* The coatings are produced by spraying molten metal on the base metal with a compressed gas.

(5493) U. S. 2,279,268 (1942). L. V. Adams (General Electric Co.), *Coating for Metals.* A coating for metals comprises a mixture of Al powder and a Zn soap dispersed in a solvent.

(5494) U. S. 2,289,614 (1942). A. Wesley and H. Copson (International Nickel Co.), *Nickel Coated Ferrous Articles.* A Ni coating for Fe comprises Ni powder suspended in nitrocellulose lacquer or collodion.

(5495) French 882,372 (1943). Licentia, Patent-Verwaltungs G.m.b.H., *Coating of Electrodes.* The electrodes are coated with a paste of Zr or Ti, and then sprayed with a porous layer of the same metal.

(5496) Swiss 226,698 (1943). F. Gfeller and L. Baiker, *Spraying of Thermoplastic Materials.* Metal wire is agitated by the explosion of a combustible mixture, so that the separated particles are melted and thrown against the base.

(5497) Swiss 229,363 (1943). F. Gfeller and L. Baiker, *Apparatus for Metal Spraying.* Wire of a metal used for coating is preheated and fused, and is sprayed by several thousands of explosions per minute by a spray pistol equipped with an explosion chamber.

(5498) U. S. 2,308,704 (1943). C. J. MacNeil, *Instrument Illumination.* The pointer and dial of indicating instruments is coated with crushed Ag to make them visible against a blacked-out background.

(5499) U. S. 2,316,041 (1943). G. E. Armentrout (E. I. Du Pont De Nemours & Co.), *Process for Simulating Hammered Metals.* A simulated hammered metal finish effect, *e.g.* on metal surfaces, is produced by using a composition containing 1-5% flake metal powders, *e.g.*, Al bronze, and spattered with a solvent for the film-forming agent to produce a hammered effect.

(5500) U. S. 2,322,702 (1943). F. F. Peterson, *Shielded Cable.* A coating film of powdered Al is used on a high voltage shielded electric cable.

(5501) U. S. 2,326,001 (1943). G. Ariotti and E. H. Bucy (Atlas Powder Co.), *Simulated Hammered Material.* A simulated hammered metal finish on smooth metal or wood is produced by a coating containing powdered Al bronze and a lacquer; the partially dried coating is spattered with a volatile solvent for the base and of a definite viscosity, to dissolve some of the lacquer and thus cause a hammered effect.

(5502) U. S. 2,326,623 (1943). E. W. Crosby (E. I. Du Pont De Nemours & Co.), *Simulated Hammered Metal Effect.* A simulated hammered metal effect is produced by spraying on a surface, particularly of metal, a composition including a flake-metal pigment, *e.g.* Al.

(5503) U. S. 2,326,814; 2,326,815 (1943). D. C. Wobbe (American Can Co.), *Plate Cans.* Al paint is used as a coating for black plate cans.

(5504) U. S. 2,330,202 (1943). J. B. Brennan, *Electrode for Condensers.* A conductive and porous layer of Al is produced on electrodes by spraying finely divided molten Al metal on a metallic base and simultaneously directing a current of fluid against the base, to maintain the surface of the base at a temperature lower than the melting point of the sprayed metal.

(5505) U. S. 2,335,316 (1943). A. P. Shephard (Metallizing Engineering Corp.), *Apparatus for Conditioning Metal Surfaces.* An apparatus for conditioning metal surfaces by the application of metal coatings by spraying is described.

(5506) U. S. 2,338,713 (1944). S. Ewing, *Half Cell Electrode.* An electrode has a plating of sponge Cu on a metallic base.

(5507) U. S. 2,342,738 (1944). G. W. Jernstedt (Westinghouse Electric & Mfg. Co.), *Coating for Metals.* A corrosion-resistant coating compound for metal surfaces comprises a solution of Fe phosphate, free phosphoric acid, an oxidizing agent and powdered Zn or Cu.

(5508) U. S. 2,343,031 (1944). A. J. Spelker, *Stencil.* A metal stencil is used for imparting a design to the non-planar surface of a contoured article which has a conductive coating of powdered Fe.

(5509) U. S. 2,343,630 (1944). H. Atwood (Allen B. Du Mont Laboratories Inc.), *Shield for Cathode Ray Tubes.* The shield consists of particles of electrically conductive material of high magnetic permeability, such as pure Fe, applied in an adhesive binder to the tube.

(5510) U. S. 2,348,912 (1944). E. H. Land (Polaroid Corp.), *Producing Designs.* Designs are produced in light-polarizing areas having a metallic backing plate with a reflecting surface of Al flakes.

(5511) U. S. 2,351,940 (1944). J. Dupuis, *Electroplating of Articles.* Metallic articles with a lacquer film containing lithopone and Cu powder are electroplated.

(5512) U. S. 2,356,583 (1944). L. N. Hampton (Bell Telephone Laboratories), *Heat Transferring Element.* A heat transferring element for electrically heated soldering tool has a tapering portion of Cu, coated with powdered Fe and Al.

(5513) U. S. 2,358,171 (1944). L. B. Lindemuth (Steel Ingot Production, Inc.), *Ingot Mold.* A cast Fe mold has a crevice between the tapered circular portions of the mold and the "stool" (cast Fe base) filled with metal powders, *e.g.* Fe-Si, Fe-Cr, Fe-Mn, to prevent the molten metal seeping out between the mold and "stool."

(5514) U. S. 2,359,436 (1944). J. J. Mascuch (Breeze Corp. Inc.), *Metallic Shield.* Spark plug conductors are electroplated with metal powders.

(5515) U. S. 2,361,897 (1944). I. E. de Graaf (Hartford National Bank & Trust Co.), *Coated Bearings for Vacuum Vessel.* Ball or roller bearings for high vacuum vessels have a coating formed of Pb powder, which prevents cutting, friction and the like.

(5516) Brit. 569,784 (1945). M. Cook, G. Parker and Imperial Chemical Industries, Ltd., *Clad Metals.* Alloys of Cu and Ag are cladded onto a base metal by sandwiching a thin foil of P-Cu between the cladding alloy and base metal, heating to 645-780° C. (1190-1430° F.) and pressing to consolidate. Alternately, the P-Cu may be formed into wire and sprayed on with a spraying pistol.

(5517) Brit. 572,105 (1945). W. S. Murray, *Wear Resisting Surfaces for Bearings.* Pb is alloyed with In and used as a film of 0.001-0.03 in. thickness; it is sprayed directly on a steel or Fe backing.

(5518) U. S. 2,366,850 (1945). M. G. Gardner (Pittsburgh Plate Glass Co.), *Lining for Food Containers.* A composition for use as liner for metallic food containers contains flake Al powder.

(5519) U. S. 2,372,124 (1945). E. S. Schenkel, *Sign Construction.* An illuminated metal sign utilizes Al powder in a light diffusing coating to reflect the light.

(5520) U. S. 2,378,588 (1945). J. W. Skehan and G. I. Agule (Machlett Laboratories Inc.), *Method of Making Bearings.* Ball bearings utilize Ag particles as a coating on the working surfaces.

(5521) U. S. 2,380,047 (1945). F. W. Hyman, *Apparatus for Applying Coatings.* An apparatus for applying coatings of metal powders to rough surfaced materials of metals is described.

(5522) U. S. 2,389,702 (1945). V. G. Ullmer (Haynes Stellite Co.), *Apparatus for Treating Metal Articles.* An apparatus for coating metal articles with metal powders comprises a blow pipe, having a nozzle with a passage for powdered metals, and a passage for an oxy-fuel gas mixture.

(5523) U. S. 2,390,183 (1945). R. A. L. Seligman, *Sheet Metal Die.* Steel sheets containing the working face of the die are welded together, and the back side is built up with a mixture of metallic particles, containing one metal whose melting point is not higher than the temperature at which the hardening of the steel face plates can be accomplished; the processing is completed by heating and compressing together the face plates and the metallic mixture.

(5524) Brit. 577,979 (1946). Imperial Chemical Industries, Ltd. and J. L. Coltman, *Heat Exchange Device.* A paste of Ag powder suspended in collodion is used for thinly coating thin-walled Cu or Cu-base elements.

(5525) Brit. 578,455 (1946). Metallizing Engineering Co., *Spray Gun for Gas-Blast Spraying.* A gun for spraying powdered metals or plastics on a metal wire is described.

(5526) U. S. 2,392,879 (1946). T. J. Radcliffe (General Electric Corp.), *Coating of Electrode.* One side of an elongated metal strip is coated with a suspension of powdered antiglow metal in a volatizable binder; the coating is baked on electrically.

(5527) U. S. 2,394,065 (1946). G. W. Jernstedt and J. C. Lum (Westinghouse Electric Corp.), *Protective Coating.* Powdered Fe is used in a protective coating for nonferrous metals.

(5528) U. S. 2,408,515 (1946). A. G. Hopkins, *Coating Process.* An Sn lacquer, comprising powdered Sn held in suspension by a vinyl-resin binder, is applied to black Fe surfaces.

(5529) U. S. 2,409,514 (1946). G. W. Pratt (Radio Corp. of America), *Cathode Ray Tube.* Powdered metal coatings are used for the inner wall of a cathode ray tube.

(5530) U. S. 2,409,769 (1946). W. E. Leyshon (Sylvania Products Inc.), *Fluorescent Glow Lamp.* Powdered Zr, suspended in nitrocellulose and amyl acetate, is used as an inner coating for the electrode in fluorescent glow lamps.

(5531) U. S. 2,412,201 (1946). J. B. Brennan, *Electric Device.* Al particles are sprayed onto a wire screen to make an electrode for condensers or lightning arresters.

(5532) U. S. 2,412,528 (1946). J. C. Morrell, *Coated Metal Container.* Metal powders are used in coating tin cans.

(5533) Brit. 589,645 (1947). C. F. Lumb, *Applying Coating by Spraying.* Metal powders are flame-sprayed on a metallic surface which first has been given a flame-sprayed plastic coating.

(5534) Brit. 589,807 (1947). A. F. Berry, *Heating Apparatus for Cooking Purposes.* Powdered cast Fe or Ni is sprinkled onto enamel-coated electric hotplates made of cellular refractory material.

(5535) Canadian 442,455 (1947). Federal Telephone & Radio Corp. and M. C. Bloom, *Coating with Selenium. Cf.:* U. S. 2,426,173 (No. 5540).

(5536) U. S. 2,414,510 (1947). E. A. Doyle (Linde Air Products Co.), *Apparatus for Cladding Composite Metal Bodies.* The cladding process involves preheating the Fe metal body, cleaning the surface by a thermochemical desurfacing operation to remove a layer of the metal, *e.g.* by O_2 and a heating flame, applying the cladding material in form of a spray or powder, and compressing the composite body between rolls.

(5537) U. S. 2,414,511 (1947). H. H. Dyar (Linde Air Products Co.), *Apparatus for Cladding Metal Bodies.* The cladding is applied by subjecting the surfaces to be joined to a skinning or thermochemical desurfacing operation with O_2, applying a metal powder and a flux, and pressing the metals together.

(5538) U. S. 2,414,923 (1947). C. Batcheller, *Metal Cladding by Spraying.* Powdered metal is sprayed on a surface, so prepared that oxidation is avoided; high pressure is used to compress the sprayed particles into a dense, smooth surfaced mass.

(5539) U. S. 2,421,154 (1947). C. E. Maier (Continental Can Co. Inc.), *Aluminum Powder and Resin Spot Facing Material.* A flexible closure liner facing material for beer containers consists of Al flake powder distributed throughout the resin material, whereby the aluminum flakes are enclosed in the resin, to reduce the rate of permeation of moisture or gas.

(5540) U. S. 2,426,173 (1947). M. C. Bloom (Federal Telephone & Radio Corp.), *Coating with Selenium.* An electrically conductive base element such as C is treated with an alkaline selenide solution, such as an Na_2Se solution which is prepared by passing H_2Se through a solution of NaOH.

(5541) Brit. 596,887 (1948). The M-O Valve Co. Ltd. and R. O. Jenkins, *Thermionic Valve.* Valve grids are coated with a suspension of a 75:25 Mg-Ba alloy powder.

(5542) Brit. 598,653 (1948). Callite Tungsten Corp., *Coating of Metals with Metals and Alloys.* The metal or alloy which is to form the coating is chosen

partly from the metal powder and partly from a powdered compound, *e.g.* the oxide or nitrate; this mixture is suspended in an organic solution of nitrocellulose. Wires are passed through the suspension and then through the sintering furnace.

(5543) Brit. 602,530 (1948). Bristol Aeroplane Co. Ltd. and F. M. Owner, *Gas Turbine Blades.* A turbine blade designed for air or liquid cooling is given a coating of sintered heat-resistant ceramic material.

(5544) Brit. 603,553 (1948). Schori Metallising Process Ltd. and C. F. Lumb, *Coating Surfaces.* The metal can be flame-sprayed with paraffin wax or shellac wax which may contain a filler, such as SiO_2 or Zn dust.

(5545) Brit. 604,457 (1948). C. F. Lumb, *Production of Heat Resistant Coatings.* Metallic articles are first flame-sprayed with Al powder, then flame-sprayed with a coating of mixed Ni-Cr-Al, and finally heat treated.

(5546) Brit. Appl. 13310/48 (1948). Charles Hardy Ltd. and W. N. Pratt, *Metal Powder Product.* Flame-spraying of metal powders which form highly refractory oxide films on passing through the oxidizing zone of the flame, *e.g.* stainless steel, alloys of Cr or Al, is facilitated by coating the particles with a silicone resin.

(5547) Brit. Appl. 13311/48 (1948). Charles Hardy, Ltd. and W. N. Pratt, *Aluminum Steel-Backed Bearings.* Steel strip is heated to 480° C. (896° F.), and a molten layer of Al is built up by flame-spraying the powder with a neutral or reducing flame, using as carrier gas He, mixed with N_2 or CO_2.

(5548) French 937,824 (1948). Industrial Metal Protectives, Inc., *Protective Coating for Metallic Surfaces.* Zn powder is suspended in water glass having an $Na_2O:SiO_2$ ratio of 1:2.6.

(5549) French 944,627; 944,628; 947,479 (1948). G. Bourdillion, *Pistol for Metallizing by Means of Powders.* The arrangement of the ducts and the powder container in a flame-spraying pistol is described; the pistol may be used for sand-blasting.

(5550) U. S. 2,434,855 (1948). J. L. T. Kosterlitzky, *Coating Metal Articles.* An article containing Cu is rubbed with a mixture of 22 parts of $FeCl_2$ and $SnCl_2$, 10 parts powdered Zn, 20 parts K bitartrate, 9 parts NH_4Cl, 20 parts $NiSO_4$, 55 parts Ni ammonium sulfate, and 6 parts NaCl.

(5551) U. S. 2,437,612 (1948). H. Osborg, *Plating Magnesium Electrolytically with Zinc.* The process entails using a specially treated cyanide bath with an Mg test cathode to deposit a continuous adherent coating of Zn.

(5552) U. S. 2,438,205 (1948). J. E. Coates (Douglas Aircraft Co. Inc.), *Measuring Instrument.* The device is manufactured by depositing a film of conductive material upon the body in form of a grid of the desired shape by means of a stencil, formed with an opening of the shape of the grid, and depositing through the opening a metallic coating of Cu or bronze onto the body.

(5553) U. S. 2,438,967 (1948). H. D. Ellsworth (Indium Corp. of America), *Indium-Gold Surfaced Article.* The coating comprises a surface film with 10% In in the alloy, an underlayer of Au containing 8% In and an intermediate layer in which the proportion of In increases towards the surface.

(5554) U. S. 2,440,969 (1948). V. C. Nightingall, *Protective Coating for Ferrous Metal Surfaces.* A hard protective coating on Fe metal surfaces is produced by applying a composition of Zn and Pb powders, which are incorporated in an aqueous solution of alkali silicate and $NaHCO_3$ and drying the applied coating.

(5555) U. S. 2,442,485 (1948). F. C. Cook, *Method of Coating Hot Rolled Ferrous Products.* The products are coated by passing the hot bodies from the deoxidizing gas chamber into the coating chamber filled with vapor of the coating metal, while controlling the temperature of the bodies in the coating chamber, to condense the coating metal on the spongy surface of the bodies, causing it first to alloy and then forming the coating.

(5556) U. S. 2,444,422 (1948). V. H. Bradford (Specialities Development Corp.), *Aluminum Coating for Steel.* The Fe base is subjected to nascent N; the nitrided base is then coated with Al by spraying and then passed into a furnace.

(5557) U. S. 2,444,914 (1948). J. B. Brennan (Everett D. McCurdy), *Electrolytic Device.* The device comprises a thin sheet of metal having pierced openings for the flow of the ions; the openings are surrounded by minute projections composed of the displaced material, and both sides of the sheet are sprayed with metal particles.

(5558) U. S. 2,446,387 (1948). T. F. Peterson, *Shielded Cable.* A cable which has a surface conductivity of 10,000 ohms per inch is coated with a lacquer of a flexible oil-extended phenol-aldehyde resin in a volatile solvent containing dispersed metal powder.

(5559) U. S. 2,450,850 (1948). W. H. Colbert and A. R. Weinrich, *Coating by Evaporation of Metals.* The coating is applied by evaporating a metal, *e.g.* Cu, (as an alloy with Ca) from a filament of W, Mo, Ta; heating causes the metal to wet and to spread out over the surface of the filament, and to deposit a coating on a polished support material.

(5560) U. S. 2,454,910 (1948). W. P. Carr (De Vilbiss Co.), *Method of Applying Coatings.* Surfacing of a molded article is effected by coating the mold surface with an adhesive of non-permanent nature, by partially embedding in it inert particles, such as Al flakes, Au bronze or abrasive material, and filling the mold with the molding material; after hardening, the article is withdrawn, and the adhesive is removed, leaving the inert particles fixed in the molded article.

(5561) Brit. 609,644 (1949). Schori Metallising Process Ltd. and C. F. Lumb, *Method of Coating Metal Surfaces with Metals.* Improved results are obtained by flame-spraying metal powder mixed with a small amount of a plastic material for pore filling; *e.g.*, steel sheet is sprayed with Zn powder mixed with 3% polyethythene.

(5562) Brit. 621,244 (1949). Schori Metallising Process Ltd. and W. D. Jones, *Coating of Surfaces.* Corrosion-resistant coatings on Fe or steel are obtained by flame-spraying an Al alloy powder with 30-40% Mg or 10-20% Zn.

(5563) Brit. 623,212 (1949). Chemal Trust, *Apparatus for Deposition of Aluminum Coating.* The coating is built up by repeated applications of alternated Al paste and Al powder to both sides of Fe sheets; each application is followed by sintering and equalizing the layers.

(5564) Brit. 624,066 (1949). N. V. Enkes, *Atomizer for Discharging Molten Material.* In a pistol used for flame-spraying metal powders, ducts which are exposed to wear are made of WC.

(5565) Brit. Appl. 2631/49 (1949). Radio Corp. of America, *Non-Alloying Zirconium Coating Material.* Zr coatings, on anodes of Fe or Mo in electron discharge tubes, are prevented from alloying with the base by diluting Zr hydride of Zr metal powder with pure ZrO_2.

(5566) Swiss 255,979 (1949). A. Jenny, *Heat-Resistant Surfaces on Iron and Steel.* The coatings are produced by spraying with Al or Al alloys at 250° C. (480° F.) so that part of the coating alloys with the base metal.

(5567) U. S. 2,457,806 (1949). E. R. Crippa, *Inductance Coil.* The coil has a coating comprising a wax or resin binder and particles of finely divided Fe.

(5568) U. S. 2,458,839 (1949). J. R. Dyer and T. J. Rowan (The Indium Corp. of America), *Electrodeposition of Indium and Its Alloys.* The bath compounds may be made up in powder formed and dissolved in water at the time of use; in one example, a flat anode of Pb and In powder compressed into plate form is used.

(5569) U. S. 2,461,556 (1949). E. T. Lorig (Carnegie-Illinois Steel Corp.), *Method and Apparatus for The Electrolytic Coating of Metal Strip.* The anode may assume the form of a meshlike body in which filaments of plating metal are interwoven with each other for use in this form, or as a carrier strip upon which the plating metal may be deposited in powdered or granular form and sintered or otherwise fixed upon the backing.

(5570) U. S. 2,462,157 (1949). W. E. Blackburn (Westinghouse Electric Corp.), *Method of Eliminating Porosity in Crystalline Selenium Films.* After forming the Se coating, the coated plate is immersed in a solution of NaOH in glycerine; after annealing, the Se surface is Schoop sprayed with an alloy comprising 75% Sn and 25% Cd.

(5571) U. S. 2,462,681 (1949). V. J. Schaefer (General Electric Co.), *Method of Forming Germanium Films.* A method of forming a coating of Ge on a solid surface comprises bringing the reducing portion of a low velocity gas flame (from a Bunsen burner) into contact with a mass of powdered Ge oxide and bringing the tip of the flame into contact with the surface to be coated.

(5572) U. S. 2,462,763 (1949). V. C. J. Nightingall (Di-Met Proprietary Ltd.), *Protectively Coated Ferrous Metal Surfaces.* A method involves applying to the Fe surface a coating of a composition comprising finely divided metallic Zn incorporated in an aqueous solution of an alkali silicate, and converting the coating to an insoluble condition by reacting it with CO_2.

(5573) U. S. 2,463,342 (1949). S. B. Wiczer, *Metallic Coatings.* A hot-rolled Mg sheet is treated with Al or Mg metal powder and an oxide of a metal which will slow down oxidation, such as B_2O_3, and another oxide tending to form a slight coating, such as BeO.

(5574) U. S. 2,472,760 (1949). H. L. Ratchford (Sylvania Electric Products Inc.), *Electrode for Electron Discharge Devices.* The wire grid electrode comprises an alloy of approximately 96% Pt and 4% W and is sprayed with a lacquer suspension of W powder of approximately 325 mesh and is then mounted in conventional manner.

(5575) U. S. 2,475,601 (1949). A. O. Fink (The Commonwealth Engineering Co. of Ohio), *Bonding of Metal Carbonyl Deposits.* A Cu base is coated with Ni by first being exposed to a CO_2 atmosphere containing 1.4% by volume of $Ni(CO)_4$ for about 2 minutes while the Cu base is heated to 190° C. (375° F.); the coated base is then heated for about 15 min. in an atmosphere of natural gas and is then exposed to a $Ni(CO)_4$-containing gas until a coating of the desired thickness is obtained.

(5576) U. S. 2,485,176 (1949). F. D. Waterfall (Imperial Chemical Industries Ltd.), *Selective Carburization of Metals.* A stopping-off composition for use in selective carburization comprises a solution containing a volatile solvent of a lacquer which dries to a hard film and has suspended therein a metal powder formed of Cu mixed or alloyed with up to 15% Sn, together with a minor proportion of Pb_3O_4.

vi. Cementation and Impregnation

(5577) U. S. 701,298 (1901). S. Cowper-Coles (Sherardizing Syndicate, Ltd.), *Process of Depositing Metals on Metallic Surfaces by Cementation.* Zn is deposited on a metallic surface by applying pulverulent Zn to the surface and heating.

(5578) U. S. 910,369 (1909). F. W. Gauntlett (Sherardizing Syndicate Ltd.), *Depositing Metals upon Metal Articles by Cementation.* To coat metal articles, finely divided metal is mixed with powdered SiO_2 or C, packed around the article, and the whole is heated.

(5579) U. S. 948,663 (1910). A. Sang, *Coating Metals by Cementation.* Fe or steel articles are coated by immersing them in Cu or Zn dust and passing electric current through them.

(5580) U. S. 986,504 (1911). A. J. Rossi (Titanium Alloys Manufacturing Co.), *Process for Treating Metal Bodies.* To coat steel with Ti, a powdered alloy of Ti and Fe is packed against the steel body and heated.

(5581) U. S. 1,014,749; 1,014,750 (1912). C. F. Burgess (United States Sherardizing Co.), *Coating Metal Parts with Metal.* To coat Fe or steel articles, Zn-Fe powder in granular form is applied to the surface and the whole heated.

(5582) U. S. 1,091,057 (1914). E. G. Gilson (General Electric Co.), *Process of Treating Metals.* To protect metals against corrosion they are heated in a non-oxidizing atmosphere with a powdered mixture of pure Al, Al_2O_3 and a chloride.

(5583) U. S. 1,155,974 (1915). T. Van Aller (General Electric Co.), *Treatment of Metals.* To protect Fe or Cu bodies from oxidation they are heated with Al powder to alloy the Al with the surface.

(5584) U. S. 1,157,283 (1915). M. A. Atuesta (General Electric Co.), *Black Finish.* Before being given a black finish Fe articles are sherardized by coating with Zn dust of 80 to 92 percent metallic Zn.

(5585) U. S. 1,169,529 (1916). E. F. Collins (General Electric Co.), *Process of Sherardizing.* Zn dust of 80 to 92 percent purity is found most desirable in coating metals.

(5586) U. S. 1,178,551 (1916). G. Stolle and A. Hocks, *Cementation of Steel Articles.* Fe articles are locally heated and powdered metal or alloy and C is sprayed on the surface to harden it.

(5587) U. S. 1,244,414 (1917). E. Bernheim, C. F. Burgess and C. J. Kirk, *Coating Iron.* Fe articles are coated with Zn by heating them in 50% Zn powder and 50% Al powder.

(5588) U. S. 1,294,001 (1919). D. R. Ward, *Dry Galvanizing.* Finely powdered Zn is mixed with flake graphite in the powder pack, which permits a higher percentage of Zn to be deposited.

(5589) U. S. 1,312,716 (1919). M. M. Wise, *Coating Metals.* Sheets to be dry galvanized are curved and stacked together with metal powder between them, and spaced apart by asbestos strips, to prevent deforming of the sheets.

(5590) U. S. 1,346,062 (1920). W. E. Ruder (General Electric Co.), *Process of Treating Metal Surfaces.* Metals are rendered inoxidizable at high temperatures by surface alloying in contact with Al powder.

(5591) U. S. 1,365,499 (1921). F. C. Kelley (General Electric Co.), *Surface Alloyed Metal.* Fe or steel is heated with powdered Cr under non-oxidizing conditions, to form a surface alloy.

(5592) U. S. 1,366,963 (1921). M. Schweinert and H. P. Kraft, *Tire Valve.* Bores in tire valves are rust-proofed by revolving the casings and Zn dust in a barrel; application of heat results in Zn impregnation.

(5593) U. S. 1,513,349 (1924). O.V. Stewart and L. McCulloch (Westinghouse Elec. & Mfg. Co.), *Method of Sherardizing.* Zn dust containing 65-75% metallic Zn and 3-7% Fe is applied to metallic articles in a revolving barrel with application of heat.

(5594) U. S. 1,718,563 (1929). F. C. Kelley (General Electric Co.), *Protecting of Metals.* The protection of metals against oxidation at high temperature involves heating in H_2 with a mixture of powdered Cr and Si.

(5595) U. S. 1,853,369 (1932). L. H. Marshall (The Technimet Co.), *Chromium Alloy Coatings.* Cr alloy coatings for C steel articles are obtained by heating the bodies in contact with -6 mesh Cr and a bleaching powder; the bleach is dissociated, giving off a halogen, which displaces any air in the treating chamber.

(5596) U. S. 1,894,523 (1933). J. M. Samuel, *Container for Hot Comminuted Material.* A container of thin metal is made so that some of the particles of the hot material introduced into the bin are caused to form a lining along the inside walls.

(5597) U. S. 1,899,569 (1933). G. H. Howe (General Electric Co.), *Coating Metals.* Fe is given a smooth Cr coating at low temperatures by using a mixture of granular Zn and Cr powder.

(5598) French 786,715 (1935). F. Bergmann, *Diffusion Alloys.* The diffusion of a metal, such as Ni, Cr, W, Mn or Si into the surface of another metal, such as Fe, takes place in a neutral atmosphere of a fused mass of salt; the diffusing metal is melted as a powder with the salt.

(5599) U. S. 2,009,573 (1935). A. F. Bradley (Northwestern Barb Wire Co.), *Dry Galvanizing.* Wire is dry galvanized with a Zn dust by drawing the wire through a heated, agitated bed of the dust.

(5600) U. S. 2,046,629 (1936). H. K. Ihrig (Globe Steel Tubes Co.), *Process of Cementation.* Fe or steel is heated in contact with an organic salt of an acid of Ni; the salt decomposes to cause adherence of the Ni powder to the surface.

(5601) Brit. 474,064 (1937). Drake, McGee & Hallsted, Inc., *Metal Surfacing.* The coating material, *e.g.* powdered Al, has an alloying affinity to the metal body, *e.g.* Fe; the surface-treating temperature is below the fusing temperature and higher than the annealing temperature of the coating metal.

(5602) U. S. 2,071,533 (1937). H. K. Ihrig (Globe Steel Tubes Co.), *Process of Cementation.* The process consists of heating the Fe or steel article under non-oxidizing conditions in contact with oxides of P and Cu at temperatures sufficient to decompose the oxides.

(5603) U. S. 2,097,024 (1937). W. Enders, *Protective Layer on Iron.* Fe or steel is coated by packing it into a mixture of Al and Si powders and heating.

(5604) U. S. 2,105,888 (1938). C. F. Lauenstein and P. F. Ulmer (Link-Belt Co.), *Coating Metals.* A Si coating is applied by heating the bodies to be coated in contact with powdered Si and NaCl.

(5605) U. S. 2,109,485 (1938). H. K. Ihrig (Globe Steel Tubes Co.), *Impregnation of Metals with Silicon.* Impregnation of metals with Si is effected by heating them in contact with a siliconizing agent such as powdered Si, ferro-Si or SiC.

(5606) Brit. 498,371 (1939). Petrie & McNaught Ltd. and H. Shaw, *Coating Aluminum Bearing Members.* An Al piston has its surface coated with Zn or Cd dust at temperatures of 370-540° C. (700-1000° F.).

(5607) U. S. 2,142,941 (1939). H. K. Ihrig (Globe Steel Tubes Co.), *Impregnation of Metals with Silicon.* The article is packed in Si-bearing powdered material, and heated under non-oxidizing conditions to the cementing temperature; then Cl_2 gas is passed into the container, whereby the article is impregnated with Si.

(5608) U. S. 2,157,594 (1939). H. S. Cooper (Cooper Products Inc.), *Method of Chromizing.* Fe metal is embedded in Cr powder and $FeCl_2$, and heated in a closed vessel.

(5609) U. S. 2,157,902 (1939). H. K. Ihrig (Globe Steel Tubes Corp.), *Impregnation of Metals.* Metals are impregnated with Si by heating the article in a container in contact with a mixture of Fe_2O_3 and SiC to 700° C. (1300° F.) in a Cl-supplying atmosphere for a time sufficient to effect the penetration of Si to a desired depth.

(5610) U. S. 2,163,753 (1939). H. K. Ihrig (Globe Steel Tubes Corp.), *Making Hot Molding Die Plates.* Preformed inserts, having a Si-rich surface coating, are disposed into a mold and a metal is cast about them, so that the Si is incipiently fused and effects a bonding and impregnation with the cast metal.

(5611) U. S. 2,235,504 (1941). R. F. Rennie (Westinghouse Electric & Mfg. Co.), *Starting Electrodes.* Starting electrodes are made by burying a packed mixture of metal powders and a conductor in a second loose powder mixture of SiO_2 and graphite, and sintering the first mixture on the conductor.

(5612) German 736,448; 742,287 (1943). W. Creutzfeld and W. Koch, *Diffusion Chromizing.* To the Cr salt bath used for chromizing Fe and steel is added powdered metallic Cr.

(5613) U. S. 2,325,041 (1943). H. S. Cooper (Cooper-Wilford-Beryllium Ltd.), *Cementation with Beryllium.* A product for electric wires is formed by heating a Cu body in the presence of powdered Cu-Be.

(5614) U. S. 2,351,798 (1944). P. P. Alexander, *Coating Metal Surfaces such as Those of Copper With Alloys Containing Titanium.* A metal surface formed at least in part of Cu is impregnated with an alloy of Ti by coating the surface with a thin layer of powdered Ti hydride and heating in H_2 to above 878° C. (1610° F.) but below the melting point of Cu.

(5615) Brit. 572,703 (1945). R. L. Samuel, *Metallic Coatings on Iron and Steel.* The coatings are formed by heating the body to 1000° C. (1830° F.) in H_2 and in contact with a Cr-bearing agent; the agent is prepared by impregnating a porous ceramic with a salt of Cr, and reducing it by heating with H-halide.

(5616) U. S. S. R. 66,892 (1946). N. S. Gorbunow and I. D. Indin, *Diffusion Method for Chromium Coating of Iron or Steel.* Cr chlorides are directed onto the surface of Fe and steel parts at a temperature of 500-1200° C. (930-2190° F.) for 1-24 hours depending on the required thickness of the deposit.

(5617) Brit. 589,087 (1947). Imperial Chemical Industries, Ltd., W. P. Fentiman and K. J. Clews, *Cementation of Metals and Alloys.* A welding flux is mixed with Al powder and, optionally, Al_2O_3, and applied dry or as a suspension in a toluol solution of polystyrene, and cementation effected in a protective atmosphere at 600-800° C. (1110-1470° F.).

(5618) U. S. 2,429,221 (1947). J. A. Davis (Battelle Development Corp.), *Grain Refinement of Aluminum Alloys.* A method of refining grain structure of Al containing Mg alloys comprises bringing the alloy in contact with SiC or Mn_3C in powdered form.

(5619) Brit. 600,797 (1948). Bendix Aviation Corp., *Coating of Metals with Metals.* An Fe article is dipped into oil, then sprinkled with Cr powder; the coated article is placed in a container together with refractory material mixed with alkali metal halide; during heating, the halide is decomposed and the products form solid compounds with the oxides on the metallic surface, and reduce them back to the metallic state.

(5620) Brit. Appl. 11140/48 (1948). American Electro Metal Corp., *Blade for Gas Turbines.* A blade of Mo is surface impregnated with Pt or Cr, by decomposition of their carbonyls or iodides, under vacuum, followed by heating or diffusion treatment.

vii. Hard Facing and Surface Hardening

(5621) Brit. 221,786 (1925). W. C. Heraeus G.m.b.H., *Hard Alloy for Tipping or Facing Metallic Surfaces.* The alloy is produced by melting together, in an electric arc, W with 10-15% Pt and 1.5% C.

(5622) U. S. 1,613,942 (1927). R. D. Davies (Spengler Core Drilling Co.), *Facing Cutting Edges of Drilling Tools.* The process comprises welding to the cutting faces of the bits a hard metal containing over 75% W mixed with sufficient C to form a carbide.

(5623) Brit. 317,361 (1929). P. L. & M. Co. and H. J. Morgan, *Hard Alloy Facing.* A mass of W powder, lampblack and binder is fused and deposited on metal objects; Mo, V, Ta, Ti, Mn, Cr, Ni, and U can be used as additional elements.

(5624) German 521,139 (1931). Allgemeine Elektrizitäts Gesellschaft, *Coating with Hard Metal Powder.* The hard metal powder is blown with high velocity through an electric arc onto the work piece.

(5625) U. S. 1,803,437 (1931). H. J. Morgan, *Welding Composition for Hard Facing.* The composition has powdered W as principal ingredient for forming a hard facing on metal.

(5626) U. S. 1,824,166 (1931). H. J. Morgan, *Welding and Hard Facing Method.* Hard metal facings are formed upon softer bodies by using W ore powder in the unwrought condition mixed with C to form a homogeneous granular material, which is reduced simultaneously with fusing and welding to the surface.

(5627) U. S. S. R. 22,969 (1931). W. I. Spitzni, *Production of Hard Coating on Iron or Steel Parts.* WC or Mo_2C, mixed with glycerine, is deposited on the surface of the part and sintered at 1300° C. (2370° F.) in a reducing atmosphere.

(5628) Brit. 387,817 (1933). The British Thomson-Houston Co. Ltd. and P. P. Alexander, *Fusing Powdered Hard Material to Foundation Metal.* Fusion is effected by depositing a layer of refractory metal carbide powder on the foundation metal, and cementing the layer in a stream of H_2, blown in a long and narrow jet, and superheated by passing through an electric arc.

(5629) German 575,847 (1933). Siemens-Planiawerke A. G. für Kohlefabrikate, *Production of Bodies Containing Silicon- or Boron-Carbide.* A plastic mixture of SiC or B_4C and a binder, containing C, is first heated to coke the binder, then embedded in a powdered mixture of a material which liberates Si or B vapors; the Si or B infiltrates into the body and reacts with the C during sintering, whereby the formation of CO_2 is inhibited.

(5630) U. S. 1,971,804 (1934). P. P. Alexander (General Electric Co.), *Spraying Tungsten Carbide and Cobalt for Coatings.* WC and Co powders are mixed, heated to below the melting point of the carbide and sprayed in a neutral atmosphere on the foundation material.

(5631) U. S. 1,981,403 (1934). J. W. Weitzenkorn, *Hard Coatings on Metal Castings for Tools and Dies.* The molds used for casting are coated with a carbide of Mo or W, or with a mixture of Mo or W and C to form a carbide.

(5632) German 612,426 (1935). Haynes Stellite Co., *Welding Bar for Production of Hard Surfaces on Tools.* The bar consists of crushed hard metal carbides or borides of W and Mo, mounted on one side of the bar of the inserting metal.

(5633) German 616,840 (1935). Fried. Krupp A. G., *Welding Rod for Deposits of Hard Facings.* An Fe tube is filled with a refractory metal carbide and an auxiliary metal and sintered.

(5634) U. S. 1,993,774 (1935). J. H. L. De Bats, *Centrifugal Casting of Carbides.* A hard facing material, such as WC, with a bonding agent is applied in powdered form to dies or valve seats and sintered in place.

(5635) Brit. 448,423 (1936). P. R. Mallory & Co., Inc., *Sintered Hard Composition for Use in Facing Articles.* The composition comprises 30-65% Fe, 2-30% W, 3.5-6.5% C, 2-5% Ni, Cr, and Mo; W, Mo, or Cr is used as a ferroalloy high in C, and W and C may be partly or fully replaced by W_2C and lampblack combinations. 2-3% Si and CaB_6 may be added.

(5636) Swiss 186,611 (1936). C. Trenzen, *Production of Hard and Wear-Resistant Surfaces.* The metal body and a metal carbonyl are enclosed in a vessel and heated to a temperature above the decomposition of the carbonyl in the presence of benzol, to form a WC deposit on the body.

(5637) U. S. 2,033,594 (1936). S. M. Stoody (Stoody Co.), *Tungsten Carbide for Scarifier Teeth Surfacing.* A scarifier tooth for road scrapers has a series of grooves on its forward side, and a protective facing of WC embedded in a matrix metal of mild steel filling the grooves.

(5638) French 814,721 (1937). C. Trenzen, *Precipitated Hard Metal Surfaces. Cf:* Swiss 186,611 (No. 5636).

(5639) French 821,436 (1937). Keramet G.m.b.H., *Bodies with Surface of Carbides.* The surface of carbides is bonded to the softened body by an intermediate layer of sintered Fe carbonyl.

(5640) Brit. 495,311 (1938). N. V. Wallramite Handel Matschappij, *Articles With Protective or Resistant Surfaces.* The manufacture of articles consisting partly of carbides of "heavy metal" comprises applying finely divided heavy metals to a mold where the surfaces are to be formed, then carburizing and sintering the formed carbides, and casting into the mold a carrier metal forming the remainder of the article.

(5641) German 665,709; 666,989 (1938). Meutsch, Voigtländer and Co., *Method for the Production of Bodies with Layer of Hard Metal.* The hard metal powder is placed on an electrically conductive mold by electro-osmosis, and the layer is carburized before being sintered.

(5642) German 670,239 (1938). Deutsche Edelstahlwerke A. G. and R. Kieffer, *Coating Metals with Hard Alloys.* The coating alloy consists of 50-60% W, 2-6% C, 2-6% Ti, 5-15% Cr and 25-40% Fe.

(5643) German 672,257 (1939). Meutsch, Voigtländer & Co., *Method of Providing Supporting Bodies with Coatings of Hard Metal.* Powdered and pressed hard metal is introduced into a form which afterwards is filled with carrier metal. The hard metal is kept in the form without a binder by means of wire, netting or perforated sheet, through which a part of the carrier metal is segregated.

(5644) German 682,769 (1939). Meutsch, Voigtländer & Co., *Method of Providing Supporting Bodies with Coatings of Hard Metal.* Improvement of German 672,257 (No. 5643). Two low melting metals with different melting points are used; first the higher melting metal is sucked into the porous body of hard metal, forming a layer on the surfaces of the pores, then the remaining space is filled with the lower melting metal.

(5645) Brit. 530,639 (1940). Meutsch, Voigtländer & Co., *Method of Providing Supporting Bodies With Coatings or Inserts of Hard Metal. Cf.:* German 672,257 (No. 5643).

(5646) French 851,261 (1940). I. G. Farbenindustrie A. G., *Build-Up of Hard*

Metals on Supports. The build-up of the hard metal is effected with arc-welding electrodes, which consist of refractory metal carbides.

(5647) U. S. 2,205,864 (1940). P. Schwarzkopf (American Cutting Alloys, Inc.), *Hard Faced Bodies.* Metal bodies, such as dies or valves, have hardened surfaces made by sintering on metal powders.

(5648) Brit. 540,270 (1941). E. A. Pokorny, *Hard Facing of Metals.* A process for surface hardening of Fe and steel comprises covering the surface with a layer of Co or Ni as a binder and then arc welding on hard metal powder.

(5649) Italian 390,071 (1941). Meutsch, Voigtländer & Co., *Means for Applying Hard Metal Layers Through Welding.* Strata of hard metal, applied in form of a paste by use of gas welding torches, are characterized in that they consist of a mixture of powdered hard metal and a powder of Fe, Mn, Co, Cr, Si, Ni, Cu or the like; which mixture is applied by using a binder which evaporates at the temperature of welding.

(5650) U. S. 2,261,228 (1941). H. Cockrum (Hughes Tool Co.), *Method of Applying Hard Facing to Tools.* A hard wear resisting facing is applied to tools using a paste formed from metal powders.

(5651) U. S. 2,262,983 (1941). G. W. Woods (Hughes Tool Co.), *Method of Hard Facing.* Hard surfacing layers are applied to bushings by placing comminuted facing material in position on the bushing, heating to fusing point and distributing the molten metal uniformly by centrifugal force.

(5652) U. S. 2,275,133 (1942). E. F. Davis (Borg-Warner Corp.), *Method of Carburizing.* Steel gears are carburized by packing in their bores powdered Fe and Fe_2O_3 and placing them in a hydrocarbon gas atmosphere.

(5653) U. S. 2,279,003 (1942). M. A. Matush (A. O. Smith Corp.), *Hard Facing Material.* A tool surface is formed of sintered Ti-cyanocarbide, embedded in a matrix of a Cr-Fe alloy.

(5654) U. S. 2,292,694 (1942). P. E. Jerabek (Lincoln Electric Co.), *Hard Facing Material.* Objects such as earth working tools are hard faced by melting on their surfaces, with an electric arc, a mixture of metal powders, such as Fe, Cr, Ni, C and a boride.

(5655) U. S. 2,307,005 (1942). S. Ruben, *Boriding Refractory Metal Bodies of Tungsten or Molybdenum.* Refractory metal bodies that are to be hard faced are placed in a chamber electrically heated to 1500° C. (2730° F.). B-hydride is then introduced into the chamber to produce boriding of metal bodies without wasteful decomposition of the gas adjacent to the walls.

(5656) Brit. 552,388 (1943). H. S. Hatfield, *Coating the Surface of Solid Bodies.* Fe, steel, or other suitable metals are coated with WC or other hard metal carbides.

(5657) Brit. 558,074 (1943). C. F. Lumb, *Hard Corrosion-Resistant Alloy Surfaces on Metal Articles.* The surfacing process comprises spraying powdered Cu-Be alloy on the surface of the article and subjecting it to a heat treatment.

(5658) U. S. 2,367,978 (1945). W. C. Troy (Westinghouse Electric & Mfg. Co.), *Nitriding Hardening Treatment.* In the process of hardening of metals by nitriding, comminuted Sn is utilized to protect surfaces not to be hardened.

(5659) Brit. 582,718 (1946). Callite Tungsten Corp., *Hard Facing Alloy.* A facing alloy for dies and cutting tools is made from powders to ensure homogeneity.

(5660) U. S. 2,399,551 (1946). P. H. Kramer (Park Chemical Co.), *Surface Coating by Powder Impregnation in Selective Carburizing.* A steel article is carburized in molten bath of salts containing NaCN by coating a portion of article with a liquid vehicle adapted to dry into an adherent film that will burn off in its entirety at carburizing temperatures; in this vehicle is suspended a mixture of powdered metals, such as Sn or Pb, 1 part Al, and 4-50 parts powdered Cu.

(5661) Brit. 587,827 (1947). Hardmetals Ltd. and L. Wachtel, *Nozzles Having Abrasion- and Heat-Resisting Surfaces.* A carbide coating is welded, sprayed, or sintered onto a core of Fe, mild steel or graphite, which is then machined out, and finished by sand blasting.

(5662) Brit. 588,239 (1947). Specialities Development Corp., *Aluminum Coated Surface Hardened Steel.* The steel articles are first nitrided, then Al coated and heat-treated at 200-500° C. (390-930° F.).

(5663) Brit. 591,880 (1947). B. Landau and H. de Wilde, *Process for Coating Surfaces with Hard Alloys.* WC powder, contained in a tubing of steel, is sprayed through a wire-spraying gun.

(5664) U. S. S. R. 67,611 (1947). A. A. Abinder, *Hard Coating for Metallic Surfaces.* A solid powder of a hard compound is applied on a metal surface and is, in turn, covered by a layer of a viscous metal, and the whole is heated until the coating metal softens; the process is finished by pressing in dies or rolls.

(5665) French 937,036 (1948). La Soudure Autogène Française, *Welding Rods Containing Hard-Metal Powder.* Hard facing is carried out with welding rods coated with a mixture of 90% WC and 10% powdered borax.

(5666) U. S. 2,435,273 (1948). H. S. Hatfield, *Method of Coating with Tungsten Carbide.* The surface of the article, coated with WC powder, is subjected to a focussed beam of cathode rays for a time sufficient to alloy the surface and the carbide.

(5667) Brit. 618,429 (1949). S. A. Le Carbone-Lorraine, *Hard-Surfacing Electrodes.* Welded carbide coatings are obtained with electrodes made of mild steel tubing which are filled with sintered and crushed WC-Co.

(5668) U. S. 2,462,056 (1949). R. B. McCauley, *Hard Alloys.* The alloy will meet an Rockwell "C" hardness test of 65 to 70 and can be produced in the form of welding rod, strip metal, powder, etc., to be united by any of the known methods of fusion as a protective coating on metal objects.

viii. Chemical Reagents and Catalysts

(5669) U. S. 839,371 (1906). T. A. Edison (Edison Storage Battery Co.), *Method of Coating Chemically Active Material with Flakelike Conductor Material.* A battery grid pocket material is made by coating 20-60 mesh Ni hydroxide with adhesive, then covering with flake-like metallic Ni, Co, Ni-Co or graphite.

(5670) German 241,823 (1911). A. A. Shukoff, *Production of Organic Compounds.* The process takes place in the presence of Ni, produced from $Ni(CO)_4$, which acts as a catalyst.

(5671) German 277,222 (1914). E. W. Andersen, *Vessel for Reactions of Contact Process.* Porous metal bodies having catalytic properties are used for different parts of the vessel.

(5672) U. S. 1,092,206 (1914). C. Ellis, *Finely Divided Nickel.* Ni used for catalytic purposes in the hardening of fatty oils is made electrolytically.

(5673) Norwegian 29,686 (1919). H. Schlinck, *Making Finely Divided Metal for Catalyzer.* NiO is introduced in a reducing atmosphere and electrically heated to reduce the oxide to the powdered metal.

(5674) German 397,683 (1924). V. L. Oil Processes Ltd., *Porous Catalyst.* A porous catalyst is prepared in briquette form by first partly reducing with C a mixture of a powdered metal and an organic metal compound, and then completing the reduction at a temperature high enough to sinter the reduced metal.

(5675) U. S. 1,563,587 (1925). M. Raney, *Method of Preparing Catalytic Nickel.* Catalytic Ni is prepared by fusing together Ni and Si, pulverizing the mass and dissolving out the Si with a solvent.

(5676) French 649,853 (1928). M. A. E. Mètivier, *Smoke Producing Machine.* The working mixture is composed of 40-60% hexachloroethane or propane with naphthalene, 60-30% Zn filings, 0-10% azotate of K, and $CaSi_2$

(5677) German 488,778 (1929). J. König, *Catalysts.* Metals, metal oxides, or metal carbides are formed under high pressure and sintered in a high frequency field.

(5678) U. S. 1,893,879 (1933). O. G. Bennett and J. C. V. Frazer (Catalyst Research Corp.), *Metallic Catalysts.* The production process involves preparing

a highly active catalyst of an amalgam, evaporating the Hg under high vacuum, so that the remaining metal presents a great surface.

(5679) U. S. 1,915,473 (1933). M. Raney, *Catalytic Material.* Catalytic material is prepared by treating a powdered alloy of Ni and Al or Si with H_2.

(5680) U. S. 1,946,108; 1,946,109 (1934). M. Pier and K. Winkler, *Production of Catalysts.* A catalyst of 65% H_2MoO_4 and 35% ZnO, which is very friable, is made stable by adding to an aqueous paste of the constituents 1-3% Al powder or Al bronze powder.

(5681) Brit. 423,338 (1935). British Thomson-Houston Co. Ltd., *Method of Purifying Gases.* The method consists of removing from the gaseous mixture the carbonaceous gases by chemically reacting the gases with Al droplets at 700-950° C. (1290-1740° F.) in a retort originally containing Al powder admixed with a refractory material, *e.g.* Al silicate.

(5682) German 624,104 (1935). E. Dixius, *Production of Pure Aluminum Hydroxide.* Al_2O_3 is mixed with 10-20% Al powder or its salts and heated to 800° C. (1470° F.); the annealed product is leached out with a weak solution of alkali, to produce an alkali-aluminate.

(5683) U. S. 2,000,171 (1935). A. M. Gronningsaeter (Falconbridge Nickel Mines, Ltd.), *Reduction of Oxygeneous Nickel.* Reactive Ni powder suitable for cementation of Cu is produced by a reduction process.

(5684) U. S. 2,027,316 (1936). E. S. Johnson (Calco Chemical Co., Inc.), *Catalyst.* The catalyst comprises a V compound homogeneously incorporated in gelatinous curds of hydrous SiO_2.

(5685) U. S. 2,034,896 (1936). W. S. Calcott and W. A. Douglass (E. I. Du Pont de Nemours & Co.), *Catalyst.* The catalyst comprises uniformly porous conglomerates consisting of an infusible, rigid, porous carrier coated with partially fused V_2O_5.

(5686) U. S. 2,072,861 (1937). W. J. Amend and E. W. Bousquet (E. I. Du Pont de Nemours & Co.), *Catalytic Hydrogenation of Dicarboxylic Anhydride.* Carboxylic acid is contacted with H_2 in the presence of a hydrogenating metal in finely divided form, which is associated with an acidic oxide of Cr, V, Mo, W or Ti.

(5687) U. S. 2,083,895 (1937). G. C. Connolly (Sulco Laboratories, Inc.), *Catalytic Process for Conversion of Sulfur Compounds.* Leached zeolite is cooled and then impregnated with the catalyst, which consists of Fe, Al, V, or Mn oxides for oxidation of H_2S, or Ni and Mo or their oxides for conversion of organic S compounds.

(5688) U. S. 2,118,829 (1938). H. H. Storch (Government of U. S. A., represented by the Secretary of Interior), *Preparation of Cobalt-Copper Catalysts.* The catalysts are made by heating mixtures of $CoCO_3$ and CuO at a rapid rate, *i.e.*, 350° C. (630° F.) per minute, to 900-1100° C. (1650-2000° F.).

(5689) Brit. 515,156 (1939). Siemens & Halske A. G., *Zinc Dust Mixture of Decreased Reaction Velocity.* A method of reducing the excessive speed of reaction of Zn dust as a catalyst or reagent in reaction consists of adding to the dust finely divided Pb, Sb, or Bi.

(5690) French 859,314 (1940). G. Schauly, *Porous Lead for Absorbing Gases.* $PbCl_2$, H_2SO_4, and Zn are caused to react to give spongy Pb, which, with active C, kieselguhr or MnO_2, is used for gas masks.

(5691) Brit. 551,358 (1941). J. G. Fife, *Highly Active Silver Catalysts.* Mixtures of powdered Ag and Ag_2O are shaped into pills and thereafter the Ag_2O is converted into Ag.

(5692) U. S. 2,234,245; 2,234,246 (1941). W. H. Groombridge and J. E. Newns (Celanese Corp. of America), *Metallic Composition.* A mixture of finely divided CuO and Fe is heated to sintering temperature in a non-reducing atmosphere to reduce the CuO to Cu_2O; further reduction yields a porous mixture of Cu permeated with Fe. The composite is useful as a catalyst for the hydrogenation of C compounds.

(5693) U. S. 2,245,217 (1941). K. S. Mowlds (The Glidden Co.), *Precipitation of Metals.* For precipitating unwanted metals from $ZnSO_4$ solution, 50 pounds of Zn

dust are treated with a wetting agent making it equal to 200 pounds untreated Zn dust in activity.

(5694) U. S. 2,254,806 (1941). W. Michael and W. E. Currie, *Production of Hydrocarbons.* A catalyst is produced by pressing and treating sintered Fe powder with H_2 in the presence of an alkali metal compound.

(5695) U. S. 2,292,570 (1942). R. Klemm and E. Linck, *Catalysts.* A catalyst for hydrocarbon conversion is produced by treating powdered Fe with steam to which H_2 has been added.

(5696) U. S. 2,293,359 (1942). S. Quisling, *Acetyl Salicylic Acid Preparation.* Acetyl salicylic acid which will not cake is prepared by adding small amounts of anti-electrostatic and/or interspersing agents, such as Al powder.

(5697) U. S. 2,305,657 (1942). W. R. Aehnelt, *Purifying Liquids.* Decolorizing and purifying liquids can be effected by contacting them with Al powder and an absorbent.

(5698) U. S. 2,307,421 (1943). J. Overhoff, *Silver Catalyst.* A porous Ag catalyst is produced from Ag powder and an O-containing compound of Ag.

(5699) U. S. 2,317,153 (1943). R. S. Dean (Chicago Development Co.), *Electrodeposition of Manganese.* A solution containing a salt of hydroxylamine and an impure Mn salt is agitated with powdered Mn to remove Cu and Fe.

(5700) U. S. 2,324,067 (1943). G. Connolly (Standard Oil Development Co.), *Purification of Hydrocarbons.* A catalyst for desulfurization of hydrocarbons employs Al powder.

(5701) U. S. 2,325,287 (1943). C. L. Thomas (Universal Oil Products Co.), *Conversion of Hydrocarbons.* Catalytic masses suitable for hydrocarbon conversion comprise metal powders and other ingredients formed into pellets and used as packing material.

(5702) U. S. 2,326,275 (1943). J. Zeltner, *Catalysts.* A hydrogenation catalyst is prepared by treating a powdered alloy, consisting mainly of Ni, with a weak organic acid.

(5703) U. S. 2,326,324 (1943). H. G. Berger (Socony Vacuum Oil Co.), *Insulating Oils.* The maintenance of the dielectric stability of insulating oils used in high voltage power cables is accomplished by adding a hydrogenation catalyst, such as powdered Ni, Pt or Co to the oil.

(5704) U. S. 2,327,189 (1943). V. N. Ipatieff (Universal Oil Products Co.), *Treatment of Hydrocarbons.* Dehydrogenation of hydrocarbons is effected by catalysts of metal powder, such as Cu, Zn or Al_2O_3, formed into pellets.

(5705) U. S. 2,328,140 (1943). J. H. Hahn (Monsanto Chemical Co.), *Catalyst.* A hydrogenation catalyst comprises a mixture of powdered Ni, Mg, and aniline.

(5706) U. S. 2,328,846 (1943). E. C. Pitzer (Standard Oil Co.), *Catalytic Conversion Process.* A catalyst for hydrocarbon conversion is made from metallic Al amalgamated with Hg and dissolved in dilute acid.

(5707) U. S. 2,329,933; 2,329,934 (1943). F. F. Nord (Baker & Co., Inc.), *Catalyst.* Pt metal catalysts comprise a colloidal solution of Pt, with or without a soluble V compound, dissolved in a protective colloid solution.

(5708) U. S. 2,330,664 (1943). O. G. Bennett (Carbon Monoxide Eliminator Co.), *Oxidation Catalyst.* An oxidation catalyst comprises a mixture of Pt metals with a metal oxide.

(5709) U. S. 2,331,292 (1943). R. C. Archibald (Shell Development Co.), *Catalyst.* The catalyst is produced by heating Al_2O_3 and impregnating it with a dehydrogenating metal.

(5710) U. S. 2,331,915 (1943). W. J. Kirkpatrick (Hercules Powder Co.), *Hydrogenation Catalyst.* A hydrogenation catalyst is produced by coating finely divided particles of an inert non-porous material, such as fused Al_2O_3, with a mixture of a noble metal compound and an alkali metal nitrate.

(5711) U. S. 2,339,929 (1944). A. S. Houghton (Allied Chemical & Dye Corp.), *Catalyst.* A catalytic material utilizes Ni, Cu or Co powders.

(5712) **U. S. 2,340,021** (1944). F. A. Sabia (Allied Chemical & Dye Corp.), *Catalyst.* A Ni powder catalyst is produced by passing HNO_3 vapors over Ni.

(5713) **U. S. 2,364,970** (1944). M. H. Gwynn, *Catalyst.* Catalysts are produced by treating a mass of metal, such as Ag or Ni, with a phosphoric acid and decomposing the formed salt to convert it to the catalytically active form of the metal.

(5714) **U. S. 2,373,006** (1945). R. B. Baker, *Well Apparatus.* In a means for operating a well apparatus, gradual generation of fluid pressure is produced by chemical reaction between Zn shavings and HCl.

(5715) **U. S. 2,380,995; 2,380,996** (1945). E. G. Rochow (General Electric Co.), *Preparation of Organosilicon Halides.* Powdered Si and Cu, pressed into pellets, are heated with methyl bromide.

(5716) **U. S. 2,380,997** (1945). W. I. Patnode (General Electric Co.), *Contact Masses.* A solid porous contact mass, for chemical reaction between Si and a hydrocarbon halide, is produced by firing a molded mixture of 2-45% Cu and 98-55% Si.

(5717) **U. S. 2,380,998; 2,380,999** (1945). M. M. Sprung (General Electric Co.), *Organosilicon Halides.* Powdered Si and Cu are contacted with H_2 or N_2 in addition to a hydrocarbon halide.

(5718) **U. S. 2,384,501** (1945). J. S. Streicher (American Platinum Works), *Platinum Catalyst.* The catalyst is prepared by alloying Pt with a base metal, which is removed from the alloy, leaving finely divided Pt.

(5719) **U. S. 2,391,004** (1945). F. W. Breuer (United Gas Improvement Co.), *Refining Butadiene.* Fe powder, produced by treating an Fe-Al alloy with an alkaline solution, is used as a catalyst in refining butadiene.

(5720) **U. S. 2,391,530** (1945). V. H. Wallingford and A. H. Homeyer (Mallinckrodt Chemical Works), *Metallation of Esters.* Mg turnings are catalyzed with chloroform in the metallation of beta keto esters.

(5721) **Brit. 579,246** (1946). British Non-Ferrous Metals Research Assoc., E. M. D. Smith, W. A. Baker and E. A. G. Liddiard, *Magnesium Powder for Production of Hydrogen.* Convenient supplies of H_2 can be obtained by bringing pressings of Mg powder and 20% Fe, Cu or Ni powder with 5% NH_4Cl into contact with water, sea water, or a salt solution. The Fe, Cu or Ni can be introduced as salts or oxides.

(5722) **U. S. 2,393,909** (1946). E. A. Johnson (Standard Oil Co.), *Fluidized Solid Catalysts.* In an exothermic gas phase reaction, a finely divided catalyst of Fe or Ni is contacted with a mixture of CO and H_2 at an elevated temperature; a heat-absorbing inert granular material is admixed with the fluidized solid catalyst to control the temperature of the reaction.

(5723) **U. S. 2,394,164** (1946). C. G. Gerhold (Universal Oil Products Co.), *Noncorrosive Media.* Metal powders are used in fused salt mixtures to prevent corrosion of containers.

(5724) **U. S. 2,395,263** (1946). A. L. Foster (Phillips Petroleum Co.), *Isomerization Process.* Finely divided Al or Fe is used to prepare metal halide catalysts.

(5725) **U. S. 2,395,286** (1946). J. M. Merle, *Process for Chemically Purifying or Refining Metals.* Al powder is used in a process for chemically purifying and refining metal.

(5726) **U. S. 2,395,291** (1946). R. J. Patterson (Phillips Petroleum Co.), *Catalysts.* Al powder is used in preparing a porous $AlCl_3$ catalyst.

(5727) **U. S. 2,395,307** (1946). A. G. Weber and C. H. Hamblet (E. I. Du Pont de Nemours & Co.), *Preparation of Organic Salts.* Heavy metal pellets are used in the preparation of organic salts.

(5728) **U. S. 2,396,569** (1946). D. L. Griffith and L. G. Hendrickson (Hudson Bay Mining & Smelting Co.), *Method of Purifying Electrolytes.* Powdered Zn, coated with Cu and Sn, is used to purify Zn electrolytes used in the recovery of Zn from ores.

(5729) **U. S. 2,397,485** (1946). C. E. Hemminger (Standard Oil Co.), *Hydrocarbon Conversion.* Fe particles are used in a preheater, separated from the reactor, for a hydrocarbon conversion process to avoid corrosion.

(5730) U. S. 2,405,302 (1946). D. L. Griffith and L. G. Hendrickson (Hudson Bay Mining & Smelting Co.), *Purification Agent.* A purification agent for electrolytes comprises Zn dust coated with In and Cu.

(5731) U. S. 2,407,217 (1946). S. F. Birch, F. A. Fidler and L. S. Thornes (Anglo-Iranian Oil Co., Ltd.), *Motor Fuel Constituent.* Raney Ni powder is used as a catalyst in the production of an aviation or motor fuel.

(5732) U. S. 2,408,036 (1946). C. R. Boettger (Standard Oil Co.), *Electrolytic Pinacol Production.* Powdered Cu, brass or Ni is used to make a matrix for use in electrolytic pinacol production.

(5733) U. S. 2,413,153 (1946). W. K. O'Loughlin (Commercial Solvents Corp.), *Nickel Catalyst.* A pelleted block Ni catalyst is used in the hydrogenation of nitrohydroxy-compounds.

(5734) Brit. 587,774 (1947). Standard Oil Development Co., *Process for Controlling Temperatures.* For hydrocarbon reactions requiring close temperature control at 480° C. (900° F.) and higher, "fluidizing" of metal powders is proposed; the velocity of the gases passing through the finely divided material are controlled so that the fluidized solid is maintained in a turbulent condition, to prevent variation in the temperature.

(5735) Brit. 590,654 (1947). The British Thomson-Houston Co. Ltd., *Method of Producing Organo-Silicon Compounds.* Methylchlorsilanes are made by fluidizing Si powder and methyl chloride. The Si may be alloyed with 10% Cu.

(5736) Brit. 591,149 (1947). J. E. Hackford, C. Shaw and W. E. Smith, *Production of Organo-Silicon Compounds by Grignard Reaction.* Silicone resins are made by Grignard reaction from tetra-ethoxy-silicane, Mg powder and a solvent, to effect separation of the reaction products into two liquid phases.

(5737) Brit. 591,670 (1947). The Honorary Advisory Council for Scientific and Industrial Research, *Preparing Silver Catalyst.* Mixed Ag-Ca oxalates are precipitated from the mixed nitrate solution by a Na oxalate solution and ignited in an autoclave under water in a CO_2 atmosphere.

(5738) Brit. 591,810 (1947). British Thomson-Houston Co., Ltd., *Method of Preparing Organo-Silicon Chlorides.* A Si-Cu alloy is oxidized in air for 20 hrs. at 155° C. (310° F.), crushed, and further oxidized for 5-30 hrs. at 100-130° C. (210-265° F.) before fluidizing with methyl chloride.

(5739) U. S. 2,413,868 (1947). F. E. Frey (Phillips Petroleum Co.), *Removal of Organic Fluorine.* The removal is effected by contacting the hydrocarbon material with a solid porous contact material which is catalytically active for the hydrogenation, such as various oxides and finely divided Ni deposited on an inert support.

(5740) U. S. 2,415,798 (1947). D. J. Pye and M. F. Leduc (Dow Chemical Co.), *Purification of Caustic Alkali.* Electrolytic caustic soda solution is purified from chlorate by means of powdered Fe, without increasing the Fe content of the solution.

(5741) U. S. 2,416,191 (1947). W. F. Meister (National Lead Co.), *Purification of Titanium Tetrachloride.* $TiCl_4$ is purified by mixing with it small amounts of an alkali metal hydroxide and finely divided Fe, Sn, Zn, or Cu and water, boiling the mixture under reflux conditions, and distilling off the $TiCl_4$.

(5742) U. S. 2,417,041 (1947). G. W. Ayers, D. M. Barton and E. E. Harton (Pure Oil Co.), *Removal of Sulphur Compounds from Oil.* A reagent is prepared of a reacting powdered alloy composed of a metallic hydrogenation catalyst, such as Ni or Cu, and metals which are readily attacked by the alkali metal hydroxide solution, *e.g.* Al, Si, Be, or Zn.

(5743) U. S. 2,417,558 (1947). A. W. Laird and G. J. Maxson (Western Electric Co.), *Manufacturing Nitrogen.* The N_2 is produced by heating Cu particles in a furnace to 760° C. (1400° F.) and then passing O_2 and N_2 over the hot Cu, maintaining the pressure of N_2 in the furnace above atmospheric pressure.

(5744) U. S. 2,418,175 (1947). B. M. Higginbotham (Linde Air Products Co.), *Ignition Catalyst Treatment.* A method for using powdered catalyst to start reaction employs only a few particles of the ignition catalyst powder for each ignition and discards these with the products of combustion; the Pt catalyst is carried as a thin deposit on finely divided Al_2O_3, $CaCO_3$, or C.

(5745) U. S. 2,419,931 (1947). A. R. Frank and R. B. Booth (American Cyanamid Co.), *Producing Magnesium Cyanide.* Powdered Mg is added to liquid NH_3 mixed with HCN in an amount insufficient to convert all NH_3 to NH_4CN; the Mg-cyanide-ammoniate precipitates from the menstruum containing free NH_3.

(5746) U. S. 2,420,218 (1947). G. W. Ayers (Pure Oil Co.), *Sweetening Hydrocarbon Oils.* S compounds are removed from hydrocarbon oils by contacting them with a solution of alkali earth hydroxides and carbonates in the presence of Cu or Ni plus some amount of Si, Be, Al or Zn.

(5747) U. S. 2,420,558 (1947). J. C. Munday (Standard Oil Development Co.), *Catalytic Conversion of Hydrocarbons.* A "fluid" catalyst process in which high catalyst concentration and high circulating rates and short contact times are provided uses metal powders; the catalytic solids are prepared by grinding.

(5748) U. S. 2,421,421 (1947). A. J. Hoiberg (Lion Oil Co.), *Treating Hydrocarbons.* $AlCl_3$, $ZnCl_2$ and BF_3 are used in conjunction with finely divided metal promotors as catalyst.

(5749) U. S. 2,422,501 (1947). B. E. Roetheli (Standard Oil Development Co.), *Chemical Reactions in Presence of Powder.* Powdered metals or alloys, carborundum powder or silica gel are used for carrying out chemical reactions requiring high temperatures and short reaction periods.

(5750) U. S. 2,422,670; 2,422,671 (1947). V. Haensel and V. N. Ipatieff (Universal Oil Products Co.), *Demethylation of Paraffinic Hydrocarbons.* A catalyst of 66% Ni, 30% diatomaceous earth, and 4% O in form of an Ni oxide is used for the demethylation.

(5751) U. S. 2,424,811 (1947). M. L. Freed (Seymour Manufacturing Co.), *Flaked Catalyst Composition.* A catalytically active composition containing Ni flakes, dispersed in a solidified oleaginous substance, is used as a protective medium.

(5752) U. S. 2,426,761 (1947). A. Cambron and F. L. W. McKim (The Honorary Advisory Council for Scientific and Industrial Research), *Silver Catalysts.* A solution of $AgNO_3$ and a minor amount of $Ca(NO_3)_2$ is mixed with Na oxalate solution to precipitate Ag and Ca oxalates; further processing involves mixing them with water to a slurry and heating it to decompose the Ag oxalate, to form a catalyst of fine Ag powder and Ca compound.

(5753) U. S. 2,426,929 (1947). B. S. Greensfelder (Shell Development Co.), *Hydrogenation of Liquid Carbonaceous Material.* The catalysts used in a fixed bed, are sulfides of W, Ni, Fe, Mo, or Co; the corresponding oxides of these metals may also be used. The sulfide or oxide catalysts are formed in place by the reaction of the free metals or alloys with S or O compounds in the oil to be treated.

(5754) U. S. 2,429,416 (1947). C. E. Lesher (Pittsburgh Coal Carbonization Co.), *Low Temperature Carbonization Process.* The process is carried out by subjecting the coal to a low temperature carbonization and admixing ZnO in such an amount that balls of a semi-coke are formed.

(5755) U. S. 2,431,601 (1947). J. H. Young (E. I. Du Pont De Nemours & Co.), *Production of Sodium Ferrocyanide.* $Na_4Fe(CN)_6$ is produced by reacting a solution of NaCN and Fe powder at 90-110°C.(194-230° F.) and passing air into the reaction mixture.

(5756) Brit. 601,938 (1948). B. Gluck, C. Shaw and W. E. Smith, *Preparation of Silico-Organic Compounds.* Silicones are prepared by using Zn dust containing 0.5-1% Cu, instead of Mg powder, in the Grignard reaction.

(5757) Brit. 603,120 (1948). Trinidad Leaseholds Ltd., W. B. Heaton and T. K. Hanson, *Combustion Chamber of Engines.* The combustion of Diesel fuels is accelerated in the presence of V_2O_5 as the catalyst. A porous metal plug of Ni-Cr alloy or Swedish sponge Fe impregnated with NH_4 vanadate, which is then reduced to V_2O_5, is fitted into the chamber.

(5758) Brit. 606,348 (1948). American Platinum Works, *Platinum Catalyst.* Pt or Pd is alloyed with Al or Zn to form an intermetallic compound. After the base metal is incompletely leached out, the residual alloy particles have a skeleton structure with a large amount of H; they must be stored under water.

(5759) U. S. 2,434,067 (1948). J. C. W. Frazer and O. G. Bennett (Catalyst Research Corp.), *Short Delay Fuse Element.* The element is composed of a mixture of S and finely divided Ni, produced by distillation of Hg from a Ni amalgam in the presence of an inert diluent.

(5760) U. S. 2,434,095 (1948). G. W. Ayers (Pure Oil Co.), *Producing Pure Phenols.* The phenols are recovered from a mixture of phenols and thiophenols by treating with an aqueous alkali solution in the presence of Al, Si, Be or Zn and Ni or Cu.

(5761) U. S. 2,438,584 (1948). M. M. Stewart (Texas Co.), *Preparation of Non-Sintered Iron Catalyst.* The hydrocarbon synthesis is carried out with a fluidized catalyst consisting of -400 mesh $FeCO_3$ which is reduced; the final composition is 95-97% Fe, 2-3% Al_2O_3 and an 1-2% oxide of K.

(5762) U. S. 2,440,673 (1948). M. C. K. Jones (Standard Oil Development Co.), *Catalyst for Refining Petroleum Fraction.* The petroleum fraction is treated with fuel gas in the presence of a catalyst containing a small amount of Pt and Pd, incorporated in an hydrous oxide carrier, and having microscopic pores.

(5763) U. S. 2,440,750 (1948). C. A. Kronis and J. D. Calfee (Standard Oil Development Co.), *Catalyst.* The catalyst consists of Al alcoholate and a Friedel-Crafts active metal halide dissolved in an alkyl halide solvent for polymerizing of hydrocarbons.

(5764) U. S. 2,451,803 (1948). D. L. Campbell, H. Z. Martin and C. W. Tyson (Standard Oil Development Co.), *Method of Contacting Solids and Gases.* In catalytic hydrogenation reactions, fluidized solid catalysts of finely divided Ni, W, Mo, their oxides or sulfides, are kept in a freely flowing condition throughout their contact with the gaseous reactants in the reaction column.

(5765) U. S. 2,456,035 (1948). B. F. Wobker (Phillips Petroleum Co.), *Treatment of Fluids with Comminuted Solids.* The treatment comprises providing a body of powdered metallic catalyst in each of two reacting chambers, together with cyclone separators for retaining the catalyst within the chambers, and then alternating each chamber on conversion and on reactivation with the fluidized catalyst bed within each chamber.

(5766) Brit. 626,353; 628,042 (1949). The British Thomson-Houston Co. Ltd., *Method for Preparing Organo-Silicon Halides.* Methylchlorsilanes are made by charging a 90:10 mixture of Si and Cu powders of definite particle size distribution through a vertical screw-feed in a chamber containing methyl chloride.

(5767) Brit. 626,398 (1949). The British Thomson-Houston Co. Ltd., *Preparing Organogermanium Halides.* A new lubricant is prepared by reacting Ge-Cu alloy powder with an aryl or alkyl halide at elevated temperatures.

(5768) U. S. 2,457,798 (1949). A. L. Ferguson (Federal-Mogul Corp.), *Production of Tin Fluoborate.* Sn, in the form of granules or powder, is used, together with HBF_4 and CuO, in making Sn fluoborate.

(5769) U. S. 2,458,107 (1949). J. H. Simons (Phillips Petroleum Co.), *Process for the Preparation of Carbon.* In the preparation of C by the oxidation of non-aromatic hydrocarbons and alcohols, HF and an O-carrier are employed as reactants. Suitable O-carriers include finely divided Ag.

(5770) U. S. 2,465,202 (1949). P. H. Craig (Invex Inc.), *Hermetically-Sealed Storage Battery with Gas Recombining Means.* Pd on Al_2O_3, V_2O_5, or finely divided Pt are usable respectively as catalysts positioned within the battery casing for combining gases in the battery into a liquid.

(5771) U. S. 2,470,784; 2,470,785; 2,470,786 (1949). M. A. Mosesman (Standard Oil Development Co.), *Iron Oxide-Alkali Metal Ferrate Catalysts.* A powdered Fe or a powdered oxide of Fe such as Fe_3O_4 or α and γ Fe_2O_3 are used in these methods of preparing a catalyst adapted for use in a Fischer-Tropsch synthesis.

(5772) U. S. 2,475,965 (1949). D. C. Hull and J. F. Quarles (Eastman Kodak Co.), *Process of Preparing a Copper Catalyst.* A process for preparing Cu catalysts for use in oxidation and de-hydrogenation of alcohols is claimed.

(5773) U. S. 2,477,443 (1949). D. J. A. Dahlgren (Hudson Bay Mining & Smelting Co. Ltd.), *Activated Zinc Dust for Gold and Silver Precipitation.* The precious metals may be precipitated from a cyanide solution by subjecting Zn dust to treat-

ment in a solution of a water soluble salt of Cu and a similar solution of Sb in proportions of about 300 parts of the Zn dust to every 150 parts of Cu and 7 parts of Sb contained in the solution.

(5774) U. S. 2,481,238 (1949). J. A. Pierce and R. W. Richardson (Standard Oil Development Co.), *Process of Preparing Group VIII Metal-On-Aluminum Catalyst.* The catalyst may be prepared by precipitating a metal from the group consisting of Fe, Co or Ni from its aqueous salt solution upon sub-divided Al by contacting the solution and the Al for 15 to 30 min., removing the solution and recovering the catalyst.

(5775) U. S. 2,484,221 (1949). E. A. Gulbransen (Westinghouse Electric Corp.), *Chemical Type Power Plant for Torpedo Propulsion.* In a chemical reaction steam boiler whose waste products are soluble in water; the reaction cell of the boiler contains Mg in finely divided form; between such reaction cell and the steam turbine or engine, there is a catalytic reaction chamber in which catalysts, such as Pt or oxides of Fe or Co, combine residual amounts of H_2 and O_2 to water in the form of steam.

(5776) U. S. 2,484,300 (1949). R. L. Mayhew (General Aniline & Film Corp.), *Process of Preparing a Sulfur-Containing Phthalocyanine Dyestuff.* The reduction step of this process can be carried out by the use of a suitable form of Fe, for example, filings, borings, or powder.

(5777) U. S. 2,492,561 (1949). H. A. Eckman (Crane Co.), *Packing Composition for Removal of Zinc from Zinc-Covered Articles.* Machined Zn-coated articles are heated in a packing material consisting of 25 to 75% Fe particles as essential components, $BaCO_3$ up to 10%, an amount of solid carbonaceous material not to exceed 10% and the balance an inert refractory material, such as sand and clay.

ix. Heat Generating, Insulating, Conducting, Reflecting, Luminescent and Radioactive Agents

(5778) U. S. 1,718,899 (1929). A. Fischer, *Uniting Radioactive Material with Carrier.* A chemical compound of radioactive material is brought into intimate contact with a metal carrier, and incorporated with it by heat treatment.

(5779) U. S. 2,029,679 (1936). F. W. Seving, A. Bergqvist and K. E. Olsson, *Insulation.* Metal flakes are intermingled with acetate cellulose foils to provide a heat-ray reflecting insulation.

(5780) U. S. 2,037,813 (1936). C. G. Munters (A. B. Termisk Isolation), *Insulation.* The insulating material comprises sheets of foil faced with Al powder.

(5781) U. S. 2,110,660 (1938). R. Doczekal (Internationale Alfol Maatschappiy), *Insulation.* Thermal insulation is composed of sheets coated with metal powder which is electrically heated.

(5782) U. S. 2,181,095 (1939). H. J. Ness (Nesaloy Products Inc.), *Heating Torch.* The O_2 absorption of an oxy-acetylene or open gas flame is increased by introducing powdered Li into the flame.

(5783) U. S. 2,250,185 (1941). O. E. Mohler (Socony-Vacuum Oil Co.), *Heat-Reflecting Temporary Coating Material.* A composition for forming a heat-reflecting, corrosion-resisting and easily removable coating comprises a suspension of Al-powder in a naphthenate solution of another metal.

(5784) U. S. 2,294,169 (1942). C. B. Francis, R. H. Noderer and R. B. Porter, *Casting Rolls.* In casting rolls for steel mills, the metal at the top of the casting is kept molten longer by covering it with a layer of thermite mixture, containing Al powder, Fe_2O_3, and fluorspar, and then covering with a wood block and a plate to protect them from air.

(5785) U. S. 2,294,170 (1942). C. B. Francis, R. H. Noderer and R. B. Porter, *Metal Casting.* In the production of metal castings, clean surfaces of steel are covered with an exothermic insulating mixture consisting of Al, Al_2O_3, fluorspar and CaC_2.

(5786) U. S. 2,311,526; 2,329,113 (1943). W. C. Ferguson and P. Sussenbach (Presstite Engineering Co.), *Heat-Conducting Material.* Luting or gum-like material incorporates up to 50% of a heat conducting metal powder such as Al flake.

(5787) U. S. 2,324,843 (1943). R. C. Hultgren and S. Isenberg (General Luminescent Corp.), *Luminescent Material.* Luminescent $MgWO_4$ is made in a temporary vehicle of methanol and a small proportion of cellulose.

(5788) U. S. 2,326,631 (1943). A. Fischer (U. S. Radium Corp.), *Radioactive Unit.* The unit consists of a highly compressed and sintered intimate mixture of radioactive salts and a powder of non-cementing metal carrier, such as Cu, Ni, W, Ag, or Au.

(5789) U. S. 2,337,314 (1943). J. H. Deppeler (Metal & Thermit Corp.), *Aluminothermic Method.* A method of manufacture of alloys comprises contacting a molten metal bath with highly compressed pellets of a thermit containing Al as reducing agent.

(5790) U. S. 2,352,951 (1944). A. Geria, *Heated Liquid Container.* A chemically heated liquid container used in skin and hair reconditioning therapy utilizes Al or Fe powder to heat the surrounding liquid.

(5791) U. S. 2,359,983 (1944). M. E. Fry (General Motors Co.), *Top Heating Unit.* In a top heating unit for electric ranges, the heating resistance is embedded in refractory material and this body is then embedded in a disk of powdered and sintered Fe.

(5792) U. S. 2,360,758 (1944). C. A. Cadwell (Electric Railway Improvement Co.), *Rail Bonding Apparatus.* A mold for cast-welding ends of rail bonds to rails utilizes an exothermic reaction employing metal powders.

(5793) U. S. 2,374,416 (1945). A. H. Chilton (J. Stone & Co. Ltd.), *Electric Regulator Pile.* The device comprises a heat conductive core and an insulating tube with metal powders between to improve heat contact.

(5794) U. S. 2,389,587; 2,389,588 (1945). T. C. Appleman (Westinghouse Electric & Mfg. Co.), *Heating Apparatus.* Powdered Cu or Al is placed in a groove of a metal body in which a sheath of electrical heating apparatus is carried.

(5795) U. S. 2,393,636 (1946). E. A. Johnson (Standard Oil Co.), *Conversion of Hydrocarbons.* Powdered metal is employed as a heat-carrier material in the conversion of hydrocarbons.

(5796) U. S. 2,398,768 (1946). C. A. Cadwell (Electric Railway Improvement Co.), *Powdered Metal Reagent for Exothermic Reaction.* Powdered metals are added to a metal charge causing an exothermic reaction charge to produce molten metal for welding.

(5797) U. S. 2,405,395 (1946). W. H. Bahlke and M. T. Carpenter (Standard Oil Co.), *Acetylene Process.* Powdered W is used as a heat transfer material in a process for making acetylene.

(5798) U. S. 2,406,815 (1946). T. M. Elfring, *Insulation.* Al powder is used in metal foils comprising a heat insulation element.

(5799) Brit. 587,789 (1947). C. F. Styles, *Means of Generating Heat from Autogenous Source.* A self-maintaining exothermic powder mixture for generating heat consists of 60% Al, 10% Mg, 20% MnO_2 and 10% $KClO_3$.

(5800) Brit. Appl. 18424/47 (1947). Metal Hydrides Inc., *Pyrophoric Alloys of Zirconium and Lead.* A pyrophoric alloy for flints is obtained by fusing a mixture of 55% Pb, 33.5% Zr and 11.5% Ti powders in A at 1400° C. (2550° F.).

(5801) U. S. 2,422,965 (1947). H. E. Hirschland and S. Ricklin (Metal & Thermit Corp.), *Aluminothermic Unit.* One part Al powder plus 3 parts Fe_2O_3 is enclosed in a compartment of cardboard or wood, having a pouring plate at the bottom made of compressed C, and an automatic tapping plate above the pouring plate which retains the powder in the container and temporarily restrains the flow of the molten Fe reaction product.

(5802) U. S. 2,424,526 (1947). W. C. White (General Electric Co.), *Electric Discharge Device.* A thermite mixture (powdered Al and Fe_2O_3) is placed adjacent to the cathode of the device to provide sufficient heat to induce electron emission, which in turn controls the current flow between the cathode and anode.

(5803) U. S. 2,426,849 (1947). M. J. Udy, *Exothermic Mixture for Use on Surfaces of Molten Metals.* An exothermic mixture comprises Fe_2O_3, oxidizing material, non-carbonaceous reducing material, and a heat-absorbing material; the mixture ignites on contact with molten metal to provide slag at a higher temperature than the metal.

(5804) Brit. 600,012 (1948). Metal Alloys Ltd. and E. Lux, *Aluminothermic Process.* BaO_2 is added at a critical temperature in the aluminothermic reduction of Cr_2O_3, in order to drive off C and S.

(5805) Brit. 600,927 (1948). E. Lux, *Aluminothermic Process.* Alloys of metals with different melting points are prepared by adding the higher melting metal to the molten base metal in an aluminothermic reaction.

(5806) Brit. 601,113 (1948). E. Lux, *Aluminothermic Process in Production of Manganese.* For the production of Mn and ferro-Mn from reduction, optimum conditions are obtained when ratio of MnO to MnO_2 is 53:47; the combined O content amounts to 28-30%.

(5807) Brit. 610,713 (1949). E. Lux, *Exothermic Process for Extraction of Metals.* In an aluminothermic process, the amount of metal retained in the slag is reduced by addition of a second exothermic mixture containing BaO_2 and H_2O.

(5808) Brit. 614,156 (1949). Centre National De La Récherche Scientifique, *Apparatus for Production of Energy by Nuclear Fission.* U or Th are used as compressed powdered metal; the reacting mass of U or deuterium should be surrounded by a neutron-reflecting casing of UC_2 or $CaCO_3$.

(5809) Brit. 627,308 (1949). L. M. Butcher and D. Clark, *Exothermic Composition for Use in Hair Waving.* Sachets with improved heat control are made from a 50-50 Mg-Fe powder mixture, diluted with kaolin.

(5810) Brit. 629,415 (1949). United States Radium Corp., *Radioactive Units.* Uniform distribution of radioactive material in a metal support is obtained by pressing and sintering a mixture of Cu with 1-2% Ra-Ba, followed by hot-forging and rolling or drawing.

(5811) Brit. Appl. 13724/49 (1949). United States Radium Corp., *Neutron Source.* A mixture of $RaCO_3$ and Be is obtained by preparing a suspension of Be powder in a solution of $RaBr_2$ precipitating with $(NH_4)_2CO_3$, stirring, adding Be powder, filtering, washing and drying.

(5812) Brit. Appl. 16381/49 (1949). S. A. Pour L'Industrie De L'Aluminium, *Heating Cartridges.* Welding cartridges are made of 5 parts Al powder, 2 parts gypsum, 2 parts water.

(5813) U. S. 2,458,483 (1949). H. E. Tatel (U. S. A., represented by the Secretary of the Navy), *Centrifugal Safety Delay Switch.* In a switch, interposed in the circuit of a projectile and held in closed position by a solder-joint, the latter is melted by heat from a percussion-ignited heater to permit the switch to be opened under action of centrifugal force. The heater pellet used comprises finely divided Fe and $KMnO_4$.

(5814) U. S. 2,459,836 (1949). E. V. Murphree (Standard Oil Development Co.), *Controlling Reaction Temperatures.* A process for controlling the temperatures of highly exothermic chemical reactions is based on carrying out the reactions in indirect heat exchange relationship with a dense layer of finely divided solid material having a melting point above the desired reaction temperature, *e.g.*, various clays, powdered metals and alloys; a gas is passed upward through the solids to maintain a fluidized layer of solids.

(5815) U. S. 2,460,022 (1949). F. I. McCarthy and C. Schandler, *Spark Plug.* For increasing heat dissipation from an electrode cap to parts of a spark plug which dissipate heat, a spindle is provided, having a bore with a compact of compressed Cu and Ag powders which transmit heat.

(5816) U. S. 2,462,241 (1949). C. W. Wallhausen and H. H. Dooley (United States Radium Corp.), *Radioactive Metal Products.* A substance capable of reducing an Au compound, and a substance which forms the insoluble radioactive compound, are added together in a reagent, thus causing co-precipitation of the Au and radioactive substance; further processing involves separating the residual solution, and compressing and sintering the product.

(5817) U. S. 2,462,517 (1949). H. W. Leverenz (Radio Corp. of America), *Method of Manufacture of Luminescent Materials.* In the manufacture of a phosphor, a compound consisting of Se and Zn or Cd or their mixtures is vaporized under pressure; an activator such as Cu or Ag is separately vaporized and mixed with the other vapors, the mixture then being co-crystallized.

(5818) U. S. 2,476,644 (1949). C. W. Wallhausen (United States Radium Corp.), *Radioactive Metallic Foil Products.* A product that emits alpha particles comprises a thin core film of pressed Au powder intimately mixed with a finely divided alpha-particle-emitting substance to which is bonded a thin Au sealing film. The latter film is free of radioactive material.

(5819) U. S. 2,479,882 (1949). C. W. Wallhausen, H. H. Dooley and C. C. Carroll (United States Radium Corp.), *Radioactive Metal Products and Method for Manufacturing.* A metal powder such as Au powder and 1-12% of a finely divided, radioactive alpha-particle-emitting substance, such as a Ra salt, are mixed together; the powdered mixture is then pressed and sintered into a compact mass. A sealing film, easily penetrated by alpha particles, is placed over the resulting core to prevent the escape of gaseous products from the radioactive disintegration.

x. Pyrotechnics (Explosives and Flash Powders)

(5820) Italian 256,554 (1928). Bombrini Parido-Delfino, *Explosives for Mines.* The explosive is composed of 70-90% NH_4ClO_4, 20-8% mono-or binitro-naphthalene, 7-1% oil and 0.1-3% Al powder.

(5821) German 502,757 (1930). Deutsche Pyrotechnische Fabriken A. G., *Method for Ignition of Reaction Mixtures Difficult to Combust.* On the surface of the ignition mixture of NH_4NO_3 and C powder is spread a fuse composed of $Ba(NO_3)_2$, Al powder and S.

(5822) Brit. 345,284; 348,657 (1931). D. Hodge and W. Eschbach, *Compositions for Blasting Cartridges.* Typical compositions contain 76.3% magnetic Fe_3O_4 and 23.7% Al powder; or 20% Al powder and 80% $KMnO_4$; or 27% Al powder, 68% $KClO_4$ and 5% paraffin.

(5823) German 562,372 (1932). Hanseatische Apparatebau Gesellschaft, *Projectile of Aluminum for Production of Artificial Fog.* The explosive charge consists of a mixture of Al powder and a phosphate.

(5824) U. S. 1,891,500 (1932). E. H. Burrows, *Explosive Composition.* The composition consists of NH_4ClO_4 and $Ba(NO_3)_2$ mixed with 1% Al powder and 9% Al granules.

(5825) Brit. 391,195 (1933). Imperial Chemical Industries and S. H. Lucas, *Light Producing Ignitable Composition.* 2 parts Mg and 3 parts Bi oxide are pressed into tracer pellets for shotgun cartridges.

(5826) French 757,444 (1933). W. Prey, *Manufacture of a Substance for Artificial Sparking Fire.* The composition consists of a mixture of 10% dextrine, 5% Al powder, 30% chips of Fe, and 50% $Ba(NO_3)_2$.

(5827) French 768,347 (1934). Les Petits-Fils de François de Wendel & Cie., *Cartridge Filled with Liquid Air.* A cartridge for explosives is filled with liquid O and Al powder mixed with ferro-Si.

(5828) Brit. 424,733 (1935). Les Petits-Fils de François de Wendel & Cie., *Explosive and Cartridge Containing Liquid Air.* An explosive contains a $MgCO_3$, metal powder and powdered resin.

(5829) Brit. 435,588 (1935). H. T. Simpson, *Explosive.* The composition comprises a mixture of Al or Al alloy and metallic oxide, *e.g.* MnO, and a nitrate.

(5830) U. S. 2,035,509 (1936). G. J. Schladt, *White Light Pyrotechnic Composition.* The composition contains 36-40% $Ba(NO_3)_2$, 6-8% $Sr(NO_3)_2$, 50-54% powdered Mg, and 2-4% paraffin.

(5831) U. S. 2,063,601 (1937). A. Hummel, *Pyrotechnic Sparkler.* A wire is coated with a slurry formed of Al powder, $Ba(NO_3)_2$, Fe filings, and a binder such as dextrin, and covered with a waterproof material such as nitrocellulose.

(5832) U. S. 2,069,612 (1937). W. E. Kirst and C. A. Woodbury (E. I. Du Pont de Nemours & Co.), *Blasting Explosive.* The explosive consists of fine NH_4NO_3 with C carriers and a metal powder as sensitizing agent.

(5833) U. S. 2,124,201 (1938). H. A. Lewis and C. A. Woodbury (E. I. Du Pont de Nemours & Co.), *Explosive Composition.* Powdered Al or C are used as sensitizing agents.

(5834) U. S. 2,126,401 (1938). M. F. Lindsley (The King Powder Co.), *Explosive.* Al or Mg powders are used as sensitizing agents; the explosive is moistened after graining and dusted with the agent.

(5835) U. S. 2,149,694 (1939). R. E. Vollrath, *Flashlight Composition.* A spontaneously inflammable composition which ignites when in contact with O_2 comprises a mixture of Al powder and pyrophoric Fe or Pb.

(5836) U. S. 2,162,910 (1939). L. S. Byers (Molex Explosives Ltd.), *Explosive.* The mixture consists of Al powder and finely shredded asbestos.

(5837) U. S. 2,168,030 (1939). H. H. Holmes (E. I. Du Pont de Nemours & Co.), *Deflagrating Explosive.* NH_4NO_3 (about 15-45%) and powdered Al (at least 1%) are used together with black powder.

(5838) U. S. 2,261,195 (1941). E. von Herz, H. Gawlick and H. Rathsburg, (E. I. Du Pont De Nemours & Co.), *Explosive Composition.* An explosive composition used for detonating rivets employs metal powders.

(5839) U. S. 2,291,983 (1942). M. Pipkin (General Electric Co.), *Flash Lamp.* The lamp has a light-giving material composed of sensitive metal powder and an oxidizing powder with binder.

(5840) U. S. 2,293,373 (1942). E. von Herz, H. Gawlick and H. Rathsburg (E. I. Du Pont De Nemours & Co.), *Explosive Composition.* A charge for explosive rivets comprises an explosive ingredient, a good metal powder conductor, and a substance of good thermal conductivity.

(5841) U. S. 2,305,561 (1942). F. F. Sylvester, *Flash Lamp.* The lamp comprises an exploding cartridge of powdered Al in a bulb filled with combustion gas.

(5842) U. S. 2,313,210 (1943). G. Weber, *Explosive Load.* A wrapper for explosive cartridges contains powdered Al, Mg and Fe, mixed with metallic oxides.

(5843) U. S. 2,314,614 (1943). E. F. Fisher, *Incendiary Bombs.* A filling for incendiary bombs consists of Mg dust mixed with paper pulp and water.

(5844) U. S. 2,315,853 (1943). J. H. Hodgson (Remington Arms Corp.), *Ammunition.* A projectile for small caliber cartridges is filled with powdered Pb and Fe_2O_3.

(5845) U. S. 2,316,358 (1943). C. A. Nickle (General Electric Co.), *Flash Powder.* Flash powder is composed of $NaNO_3$ and Mg powder.

(5846) U. S. 2,325,667 (1943). J. H. De Boer (Hartford National Bank & Trust Co.), *Flash Lamp.* Wire or powder is used to yield O_2 to supplement the gaseous filling.

(5847) U. S. 2,333,275 (1943). W. O. Snelling (Trojan Powder Co.), *Demolition Explosive.* The explosive comprises Al powder, nitrostarch and coal dust.

(5848) U. S. 2,338,719 (1944). P. G. Holt, *Surface Marking Signal.* A dummy bomb contains pale Au bronze powder.

(5849) U. S. 2,342,575 (1944). D. E. Elmendorf (General Electric Co.), *Flash Lamp.* The lamp has a bulb containing a loose filling of combustible material, such as a foil or ribbon of Al or its alloys.

(5850) U. S. 2,343,422 (1944). H. L. Rawlins (Westinghouse Electric & Mfg. Co.), *Gas Blast Circuit Interrupter.* An electric circuit interrupter of metal shavings is used as a cooling means for explosive material.

(5851) U. S. 2,344,840 (1944). S. B. Watt (Illinois Powder Co.), *Explosive Composition.* NH_4NO_3 grains are coated with gelatinized explosive nitric ester and Al powder.

(5852) U. S. 2,354,451 (1944). J. D. Forbes, *Cartridge.* A cartridge for chain shot has a fusible casing of Sn, Pb and Bi; thermit is used to melt the casing.

(5853) U. S. 2,356,149 (1944). C. O. Davis (E. I. Du Pont De Nemours & Co.), *Explosive Composition.* An explosive composition utilizes Al powder.

(5854) U. S. 2,356,210 (1944). W. Bruen (Remington Arms Co.), *Priming Composition.* An ammunition composition contains metal powders which do not oxidize easily, such as Pb, Sn, or Bi.

(5855) U. S. 2,361,495 (1944). M. Pipkin (General Electric Co.), *Flash Lamp.* A photoflash lamp contains a fulminating substance comprising a mixture of sensitive metal powders.

(5856) U. S. 2,369,517 (1945). W. H. Bagley (Development Engineering Co.), *Explosive Material.* The material comprises a compressed mixture of powdered $Pb(ClO_4)_2$ and Al powder.

(5857) U. S. 2,370,159 (1945). E. J. Hanley (Hercules Powder Co.), *Electric Squib or Igniter.* A flame producing mixture is composed of powdered Se, Pb, and Al.

(5858) U. S. 2,375,742 (1945). E. O. Kalil and W. E. Gleim (Wabash Appliance Co.), *Flash Lamp.* A photographic flash lamp employs Zr powder.

(5859) U. S. 2,383,040 (1945). C. A. Cadwell (Electric Railway Co.), *Exothermic Reaction Charge.* The charge comprises Al in an igniting powder.

(5860) Brit. 578,991 (1946). L. D. Chisman and C. A. Dixon, *Incendiary Projectiles.* The filling of incendiary bullets for machine guns is ignited by a 1:1 mixture of Mg-Al alloy powder and $Cd(NO_3)_2$.

(5861) Brit. 579,741 (1946). C. M. Cawley, J. H. Carlile and L. P. Walls, *Manufacture of Spontaneously Inflammable Powder.* About 1% yellow P is deposited on Mg powder from a CS_2 solution; when the solvent is evaporated, Mg powder instantaneously burns on exposure to air.

(5862) U. S. 2,398,287 (1946). L. D. Christie (Remington Arms Co.), *Incendiary Bullet.* The explosive charge consists of powdered Al-Mg alloy in an equal amount with $BaNO_3$.

(5863) U. S. 2,403,907 (1946). L. A. Burrows (E. I. Du Pont De Nemours & Co.), *Smoke Pot Ignition.* Powdered Al is used in making a black powder charge for an electric ignition assembly.

(5864) U. S. 2,407,597 (1946). H. R. Wright (Imperial Chemical Industries, Ltd.), *Explosive Composition.* Metal powders are used in the preparation of a low-freezing explosive compound.

(5865) U. S. 2,408,124; 2,408,125 (1946). H. J. Rolfes, *Electric Igniters.* Powdered Ni, Ag or Al is used for safeguarding electric igniters of blasting detonators against accidental firing.

(5866) U. S. 2,409,201 (1946). L. Finkelstein and H. B. Elkins, *Smoke Producing Mixture.* Zn dust and grained Al are used in producing a mixture for use in munitions.

(5867) U. S. 2,425,005 (1947). E. R. Rechel, *Incendiary Bullet.* The manufacturing process comprises filling a jacket, placing it in a mold with an incendiary composition containing metallic powder, and pressing it into a compact so as to cause a partial extrusion of the unsupported jacket tip; the extruded section is then removed.

(5868) U. S. 2,430,068 (1947). M. W. Maughan (Remington Arms Co.), *Incendiary Composition.* The composition comprises equal proportions of powdered $BaNO_3$ and an alloy of Mg and Al with 2% $Ca_3(PO_4)_2$.

(5869) Brit. 596,725 (1948). Imperial Chemical Industries Ltd. and E. M. Patterson, *Fuse Powder.* Fast burning fuses for delayed action bombs are made from pressings of Zr powder and Pb_3O_4.

(5870) U. S. 2,445,311; 2,445,312 (1948). H. H. Cooke and J. B. Holtzclaw (Stanco Inc.), *Incendiary Bomb Mixture.* The mixture contains naphtha hydrocarbons thickened with isobutylene polymers and a mixture of powdered Al, Al_2O_3 and an oxide of Fe.

(5871) U. S. 2,451,864 (1948). D. P. O'Brien, *Explosives.* The explosive mixture contains Mg, Ca_3P_2, and $KClO_4$.

(5872) U. S. 2,452,091 (1948). D. L. Woodberry, W.W. Howerton and A. Dunbar (U. S. A., represented by the Secretary of War), *Incendiary Material.* The material consists of 61.2% Fe_2O_3, 19.2% granular Al, 2.8% grained Al, 1% flaked Al, 14% $Ba(NO_3)_2$, 0.9% S, and 0.3% castor oil.

(5873) U. S. 2,457,860 (1949). O. G. Bennett and J. Dubin (Catalyst Research Corp.), *Delay Fuse Compositions.* The composition comprises intimate mixtures of powdered Zr metal, powdered metallic Ni and oxidizing agents.

(5874) U. S. 2,460,375 (1949). J. Whetstone (Imperial Chemical Industries Ltd.), *Granular or Powder Explosives and Their Manufacture.* The process comprises emulsifying a molten high explosive with an agent (agar-agar, carageen moss extract, gum arabic, gum tragacanth, etc.) in a melt which consists of NH_4NO_3 and at least one compound non-volatile at the temperature of the melt and adapted to lower the melting point of the NH_4NO_3. Al powder can be used as addition element.

(5875) U. S. 2,461,544 (1949). G. C. Hale and D. Hart, *Fuse Powder Composition.* A fuse powder contains 75% finely divided Zr and 25% finely divided S; Ti and Mn may also be used.

(5876) U. S. 2,463,709 (1949). D. M. McFarland (Atlas Powder Co.), *Ammonium Nitrate Explosive.* An explosive assembly comprises a water-pervious shell, a water-absorptive NH_4NO_3 explosive composition including a sensitizer in the shell, and a water-proof high explosive core; among usable sensitizers are vegetable oils and Al dust.

(5877) U. S. 2,464,777 (1949). L. Rubenstein and B. Campbell (Imperial Chemical Industries, Ltd.), *Lead Azide Detonators.* A composition containing 64.8 parts Pb azide, 2.8 parts Al powder, 27.6 parts Pb styphnate, 4.8 parts "ultra short fiber" nitrocellulose, and 2.4 parts $CaCO_3$, has improved cohesive properties when compressed into detonators so as to minimize manufacturing hazards.

(5878) U. S. 2,478,501 (1949). E. M. Patterson (Imperial Chemical Industries Ltd.), *Ignition Compositions.* Delay fuze powders, having a burning speed of the order of 25-50 milliseconds per cm. when compacted in metal delay tubes, consist of a mixture of finely divided Zr of less than 0.005 mm. average particle size and Pb_3O_4. The gravimetric ratio of the Zr to the Pb_3O_4 is between 20:80 and 65:35.

(5879) U. S. 2,487,632 (1949). O. G. Bennett (Catalyst Research Corp.), *Stabilized Nickel Powder.* Ni powder, useful for making fuse compositions, is produced by evaporation of Hg from a Ni amalgam and is stabilized by contacting the Ni with CO_2 prior to contact with O_2 and then heating it in a gas containing free O_2 at a temperature below that at which the Ni ignites while being so treated.

xi. Magnetic Powder Applications (Testing, Recording, Separating Agents, etc.)

(5880) U. S. 1,960,898; 1,960,899 (1934). A. V. De Forest, *Paramagnetic Particles.* The magnetic particles are coated with ZnO to prevent a metal-to-metal contact between them, which helps them to demagnetize readily when used in testing Fe or steel bodies for cracks.

(5881) U. S. 2,106,882 (1938). C. E. Betz (Magnaflux Corp.), *Paste of Paramagnetic Particles.* Powdered Ni or Fe_3O_4 is mixed to a paste, which may be diluted to a testing bath to be used in the magnetic detection of flaws in Fe or steel products.

(5882) Brit. 502,973 (1939). L. Johnson and H. Fell, *Magnetic Tests.* Fe powder is used in a fluid for detecting cracks in Fe metals.

(5883) U. S. 2,158,409 (1939). A. V. De Forest (Magnaflux Corp.), *Testing a Weld.* Finely divided magnetic particles of varying degrees of fineness are applied to the weld and subjected to a magnetic field.

(5884) U. S. 2,216,600 (1940). R. R. Moore, *Exploring Magnetism.* The magnetic flux is directed through irregular and hollow bodies for magnetic detection of flaws by means of Fe particles gathering at poles developed at the defects.

(5885) U. S. 2,217,733 (1940). A. V. De Forest (Magnaflux Corp.), *Testing Apparatus.* Paramagnetic particles are used in a body of liquid to detect flaws.

(5886) U. S. 2,333,463 (1943). J. W. Bryce (International Business Machine Corp.), *Apparatus for Recording Statistical Records.* Metal powders are used as a magnetizable material.

(5887) U. S. 2,365,253 (1944). T. De Forest and A. V. De Forest (Magnaflux Corp.), *Method of Testing Material.* Paramagnetic particles, used to reveal cracks by their attraction to the defects, are coated with water soluble dyes, to render their pattern more visible.

(5888) U. S. 2,379,947 (1945). A. F. Bandur (Western Electric Co.), *Testing Device.* An apparatus, used for detecting defects in the insulation of electric structures, has a core of pressed magnetic Ni alloy powder.

(5889) U. S. 2,398,725 (1946). A. H. Schutte, *Magnetic Separation from a Mixture of a Plurality of Components.* Magnetic separation is effected by introducing powdered Fe in non-magnetic mixtures, one component of which combines with or adheres to the magnetic particles. The combination of the selected component with the magnetic material may be merely mechanical or chemical.

(5890) U. S. 2,401,280 (1946). J. E. Walstrom, *Method for Locating Permeable Formations.* Fe powder is added to drilling fluids for wells and is forced into the permeable formations of a bore hole; a magnetic recorder is then used to locate the most permeable sections.

(5891) U. S. 2,423,287 (1947). E. L. Beisel, *Method for Deflecting Material.* A throwing machine for paramagnetic particles contains a magnetized wear plate with a deflecting surface, against which the particles are thrown and deflected towards the point of discharge, to attract a protective film of particles.

(5892) Brit. 617,792 (1949). L. Johnson, *Magnetic Particles for Crack-Detecting Fluids.* Colloidal magnetic oxide particles are made by precipitation from a mixture of Fe chlorate and chloride by caustic soda. They are then heat-treated, which increases the permeability by 50%.

(5893) U. S. 2,461,494 (1949). T. De Forest (Robert C. Switzer), *Method and Composition for Flaw Detection.* A composition for detecting flaws in metallic bodies comprises a liquid hydrocarbon, finely divided ferromagnetic particles suspended in the hydrocarbon and a fluorescent substance insoluble in the liquid which is contained on the surfaces of the ferro-magnetic particles. A non-fluorescent organic dyestuff is dissolved in the hydrocarbon.

xii. Miscellaneous Applications (Spectrographic and X-Ray Testing, Damping Agents, etc.)

(5894) U. S. 2,417,347 (1947). T. T. Brown (Lockheed Aircraft Corp.), *Vibration Damper.* A powder or granular mass or liquid is contained in rough-walled compartments, so that vibration is resisted and absorbed by the frictional contact of the particles with the walls.

(5895) U. S. 2,438,158 (1948). E. J. Dunn (Carnegie-Illinois Steel Corp.), *Spectrographic Pin Stand.* The pin may consist of a C electrode, having a cavity in which the metal to be analyzed is placed in powdered form.

(5896) U. S. 2,462,374 (1949). F. G. Firth (Philips Laboratories, Inc.), *Stress Analysis by X-Ray Diffraction.* In the analysis, a thin layer of finely powdered Au is used.

(5897) U. S. 2,468,301 (1949). W. P. Mason (Bell Telephone Laboratories), *Effective Contouring of Piezoelectric Crystal Elements.* A suitably shaped field

to be interposed between X-ray radiations and the plates, may be provided by making a casting of collodion mixed with Permalloy dust which assumes the shape of the crystal to be contoured; such field may also be formed of powdered Pb worked into clay.

(5898) **U. S. 2,469,167** (1949). C. C. Little (The American Steel & Wire Co.), *Vibration Damper.* The damper is made up of a chamber containing small particles of ferro-Mn or W; the powdered metals are loosely packed in the chamber so that when they are moved about by the vibration of the member to which the damper is attached, their energy is absorbed by the damper and the vibration of the member is quickly stopped.

(5899) **U. S. 2,483,500** (1949). R. W. Long (Standard Oil Development Co.), *Apparatus for Obtaining X-Ray Diffraction Patterns from Powders.* This apparatus is adapted for studying the characteristics of powdered metals, *e.g.* catalysts, under various conditions of temperature and pressure and in the presence of various fluid materials, such as those the catalyst will contact in actual use. The microreactor of the invention is made of a material that does not interfere with the X-ray diffraction patterns, *i.e.*, it may be made of Be, Mg, Al or their alloys.

C. Non-Metallurgical Applications

i. Addition Agents and Coatings for Glass, Sand, Ceramics, Refractories, Cements, Mica, etc.

(5900) **U. S. 211,961** (1879). R. Boettger, *Process for Bronzing.* Bronze powder is applied to porcelain, glass or wood over a coat of soluble glass.

(5901) **U. S. 218,102** (1879). A. Wohlfarth and C. Gartenfeld, *Method of Applying Metallic Powder to Floor Coverings.* Metal powders are applied to floor and wall coverings by mixing them with soluble glass and imprinting upon the surfaces before hardening.

(5902) **U. S. 258,108** (1882). A. Paul and J. H. Rouse, *Decorating Glass.* Decorative glass is first coated with adhesive, then with metal powders.

(5903) **U. S. 310,042** (1884). G. Gehring, *Process of Decorating Glass.* Glass, porcelain and metal articles are decorated with Al or Al-bronze.

(5904) **U. S. 368,839** (1887). C. Laval, *Silvering of Glass.* Glass is silvered by applying bronze powder to the final coat of Ag-lining.

(5905) **U. S. 603,296** (1898). G. W. Tooker, *Gilding China Articles.* In gilding china, Ag precipitated by Hg is used together with other ingredients.

(5906) **U. S. 610,645** (1898). J. T. Cupper, *Crystal Aluminum Bronze.* A powdered composition suitable for application as a decorative and protective coating for metal or wood contains 60% powdered Al, 35% powdered glass or diamond dust and 5% $ZnSO_4$.

(5907) **U. S. 694,227** (1901). C. P. Ahrle (Metalline Platten Gesellschaft), *Coating Photographic Plates.* Photographic plates are coated with varnish base, a softener and bronze powder.

(5908) **U. S. 830,003** (1906). J. M. Rauhoff, *Process of Rendering Cement Blocks Waterproof.* Cement blocks are waterproofed by applying powdered Fe held in suspension in water, whereby the particles oxidize and expand thus filling the pores of the block.

(5909) **U. S. 1,077,357** (1913). Q. Marino, *Metallizing Ceramics.* Ceramic surfaces are metallized by coating them with Fe or other metal fluoride and precipitating the Fe by another metal.

(5910) U. S. 1,087,098 (1914). J. W. Aylsworth and F. L. Dyer, *Porous Artificial Stone.* In a molded cement block, Al or Mg powder is used in contact with alkaline hydroxides to form gas bubbles which make the block porous.

(5911) U. S. 1,421,471 (1922). W. P. Heskett, *Metal Compound Powder and Process for the Production of the Same.* A metallic powder which is adapted for use in acid-resisting mixtures and is admixed to cements is composed of pure, fine metals in the amorphous state.

(5912) U. S. 1,539,512 (1925). T. Robinson (Anaconda Sales Co.), *Metallized Roofing Material.* Powdered Cu in nitrated cellulose is sprayed on asphalt base roofing felt.

(5913) U. S. 1,541,550 (1925). J. Wysocki (United States Industrial Alcohol Co.), *Bottle Capping.* A glass bottle is capped by applying a solution containing Al powder.

(5914) U. S. 1,574,615 (1926). C. S. Fleming, *Roofing Material.* Fibrous material is coated with bituminous material and surfaced with bronze powder.

(5915) U. S. 1,622,396 (1927). A. T. Schenck, *Porous Concrete.* Porous concrete is produced by the evolution of gas from Al powders incorporated in the mass.

(5916) Swiss 128,404 (1928). M. Hauser, *Method for Production of Metal-Ceramic Bodies.* Ceramic and metallic powders are mixed to produce the bodies.

(5917) German 521,732 (1931). Berliner Härtepulver G.m.b.H., *Cover for Case-Hardening.* The cover consists of fireclay mixed with Al powder.

(5918) Japan. 91,381 (1931). Y. Hirai, *Glazing Powdered Aluminum on China.* Figures are drawn on china with raw japan on which powdered Al is sprinkled; the china is then heated to 600° C. (1110° F.).

(5919) U. S. 1,816,922 (1931). P. H. Watkins (Naugatuck Chemical Co.), *Concrete.* The concrete has a permanent coating of rubber, bonded by a reaction product of powdered Fe and $CuSO_4$.

(5920) U. S. 1,862,191 (1932). M. Meth (Firth Sterling Steel Co.), *Refractory Articles.* Powdered ZrO_2 is mixed with water in the presence of HCl, and articles are produced by shaping and sintering. Metallic powders may be added in small amounts.

(5921) U. S. 1,863,990 (1932). W. K. Nelson (Universal Gypsum & Lime Co.), *Porous Cement.* Porous cement is produced by the evolution of gas from metal powders, such as Al.

(5922) U. S. 1,923,406 (1933). E. Wiegand (Telefunken Gesellschaft für Drahtlose Telegraphie m.b.H.), *Metallic Films for Oxide Filaments in Discharge Tubes.* Metal films are formed upon porous oxide bodies by mixing a highly comminuted metal with a viscous sugar solution which reacts with the metal and the oxide body at a high temperature to form a conducting compound.

(5923) U. S. 1,932,502 (1933). R. A. Altenhof (Koppers Co.), *Construction Material.* The material comprises a porous stone material having in its pores a S-treated tar and having on its surface a continuous film of metal.

(5924) U. S. 1,959,149 (1934). A. E. Baggs and E. Littlefield, *Colorable Ceramic Compositions.* The surface of ceramic ware is colored by coating it with a small percentage of CuO and SiC and burning the ware in ordinary kiln atmosphere.

(5925) U. S. 1,965,538 (1934). L. C. Stewart (Dow Chemical Co.), *Porous Cement.* The porosity in the cement is produced by gas resulting from a reaction with powdered Al.

(5926) U. S. 1,986,591 (1935). E. B. Meyer, *Pavement Marking.* The production of a mixture used for marking pavement comprises rendering a bituminous binder fluent and admixing PbO, Al powder and granular mineral matter.

(5927) U. S. 2,004,567 (1935). J. V. Brumbaugh, *Combination of Enamel and Sprayed Metal.* Enamel on metals or ceramics is spray-coated with metal powders and heated to fuse the enamel and metal.

(5928) German 625,049 (1936). Deutsche Gold- & Silberscheideanstalt, *Comminuted Metals for Ornamenting Pottery.* The process comprises spraying metal

salt solution onto a metal support, reducing the salt to form metal, separating the metal layer from the support by acid or alkali, and grinding the metal.

(5929) Brit. 459,231 (1937). Radioaktiengesellschaft D. S. Loewe, *Method of Producing Finely Divided Metallic Layers.* Metallic coatings or layers on an insulating material, such as Ag on mica, are formed by heating in a suitable gas atmosphere to 400-450° C. (750-840° F.); the products are suitable for transmission tubes.

(5930) U. S. 2,081,234 (1937). A. Hefter (Deutsche Gold- & Silberscheideanstalt) *Production of Precious Metal Decoration.* Stoneware or porcelain is first coated with lacquer containing Bi over which a precious metal powder is applied.

(5931) U. S. 2,103,538 (1937). F. P. Kolb (Bausch & Lomb Optical Co.), *Reflector.* A protective coating for reflectors of glass comprises powdered metallic pigments and glycerol.

(5932) U. S. 2,109,532 (1938). N. A. Hill, *Asbestos Cement.* Asbestos cement sheets are aerated by the reaction of Al or Zn powder with a caustic solution.

(5933) U. S. 2,120,468; 2,153,837 (1938). N. V. Hybinette, *Expanded Concrete.* Al flakes or powder are used as a gas producing agent.

(5934) Brit. 506,432; 506,433 (1939). Johnson, Matthey & Co., Ltd. and A. R. Powell, *Metal Powders.* The preparation of metal powders for use in decorating ceramics, in metal paints and for soldering is disclosed.

(5935) Japan. 129,105 (1939). S. Nagai, *Molded Composition of Oxides and Metal Powders.* A suitable amount of metal powder, such as Zn, Fe, Al, Mg is added to powdered refractory oxides, and a metallizing agent, such as $ZnCl_2$, $FeCl_3$, $MgCl_2$ or borax and a small amount of plasticizer, such as $Al(OH)_3$, $Mg(OH)_2$, or $Zn(OH)_2$ is incorporated into the mixture which is then molded, pressed and sintered.

(5936) U. S. 2,142,846 (1939). G. H. Howe (General Electric Co.), *Metal Boats.* Boats suitable for holding powdered alloying metals in a high temperature furnace consists of layers of Fe and Al_2O_3 combined by Fe_2O_3.

(5937) U. S. 2,150,789 (1939). G. S. Smith, *Coating Cement.* Metallic coatings on cement surfaces are produced by applying a mixture of caustic alkali and metal powder.

(5938) U. S. 2,198,601 (1940). L. T. Brownmiller (Bakelite Building Co.), *Roof Material.* High aluminate cements are expanded by H_2 gas released by Al flakes.

(5939) U. S. 2,205,734; 2,205,735 (1940). P. C. Scherer, *Insulating Material.* A porous insulating material is made with Al powder, a refractory composition and a viscose solution which generates gas.

(5940) U. S. 2,235,176 (1941). S. Schless, *Porous Plates formed on Board-Baking Machines.* Cement-fibrous wall material is mixed with Al powder applied as a raising agent on the fan belt of the board-former.

(5941) U. S. 2,236,911 (1941). B. Long, *Coated Glass.* Glass is mirrored by the deposition of powdered metal while the glass is in the tempered state.

(5942) Belgian 446,172 (1942). Siemens & Halske A. G., *Sintered Body.* A mixture of Al_2O_3 and Fe powder is sintered in two steps, first at 900° C. (1650° F.), then at 1500° C. (2730° F.).

(5943) U. S. 2,288,556 (1942). L. W. Vollmer (Gulf Research Co.), *Permeable Well Packs.* Permeable well packs are expanded by finely divided Al. A typical composition is 100 lbs. portland cement, 4 lbs. Al powder, 5.5 lbs. slaked lime, 70 lbs. water and 0.8 lb. Na_2CrO_4.

(5944) U. S. 2,295,759 (1942). C. L. Scheer (Radio Corp. of America), *Capacitator.* In a capacitator, the armature comprises powdered metal applied to mica.

(5945) U. S. 2,301,101 (1942). L. T. Welshans (Standard Lime & Stone Co.), *Hot Top.* Hot top for an ingot mold is made of portland cement in which powdered Al is incorporated.

(5946) French 883,630 (1943). Fides Gesellschaft für die Verwaltung und Verwertung von Gewerblichen Schutzrechten m.b.H., *Sintered Body.* A mixture of Al_2O_3 with 5-20% Fe is presintered, machined or pressed to the desired shape, and sintered.

(5947) U. S. 2,307,027 (1943). P. Davie and A. L. Halvorsen, *Glass Radio Tube.* A coating composition for glass radio tubes includes Cu flake powder and a vehicle.

(5948) U. S. 2,313,596 (1943). S. S. Sorem and A. P. Anderson (Shell Development Co.), *Asphalt Composition.* An unemulsified asphalt composition capable of forming a bond with galvanized metal comprises powdered Zn, Pb, their oxides or hydroxides, dispersed in asphalt to neutralize acids and thus prevent corrosion.

(5949) U. S. 2,321,587 (1943). P. Davie and A. L. Halvorson, *Electrical Conductive Coating.* An electrical conductive coating for glass envelope tubes contains metal flakes in nitrocellulose.

(5950) U. S. 2,325,553 (1943). H. M. Schleicher (Scovill Mfg. Co.), *Refractory Brick.* A refractory-faced porous insulating brick is obtained by impregnating ordinary porous brick with bonded Zr.

(5951) U. S. 2,330,418 (1943). J. A. Gitzen, *Treating Foundry Sands.* The treating composition includes pulverized coal and coke, carbon black, graphite and powdered Al.

(5952) U. S. 2,332,116 (1943). E. R. Schmid (Westinghouse Electric & Mfg. Co.), *Cement for Electric Lamp.* The lamp contains a bulb with a base secured by a cement which includes Al powder, which is adapted to bypass current upon failure of the lamp filament.

(5953) U. S. 2,332,219; 2,332,220; 2,332,221 (1943). N. P. Harshberger (Carbide & Carbon Chemical Corp.), *Roofing Material.* Roofing and siding material comprises flakes of metal, *e.g.* Al, or mica coated with metal flakes bonded to and completely covering the base material.

(5954) German 748,036 (1944). Anonymous, *Sintered Hard Material.* Al_2O_3 is mixed with Fe powder, pressed and sintered alternately in a reducing and in an oxidizing atmosphere. The process can also use a mixture of hard oxide, Fe powder and Fe_2O_3 powder, which is sintered in inert atmosphere.

(5955) German 749,934 (1944). H. Goedecke, *Bearings for Precision Instruments.* The bearing parts consist of pure Al_2O_3 mixed with 2% Cr or Cr_2O_3 oxide and are made by compacting two layers of the mixture, one of them having a volatile binder added. After sintering, the part thus consists of a hard dense section backed by a porous section, the latter suitable for oil-impregnation.

(5956) German 750,430 (1944). K. Daeves, W. Holtmann and H. Ruppik, *High Temperature Material Consisting of Sintered Mixture of Metal Powders.* The material is produced from a mixture of an alloy steel powder with up to 50% of ceramic powder, *e.g.* SiO_2, SiC or ZrO_2 to improve the creep properties at high temperatures.

(5957) U. S. 2,351,974 (1944). M. Kollmar, *Silvering Ceramic Ware.* Surfaces of ceramic ware are silvered with a composition comprising a flux, a solvent vehicle, metallic Ag and a Ni compound.

(5958) U. S. 2,357,550 (1944). D. H. Rowland (Locke Insulator Corp.), *Insulator.* A glaze is formed on a ceramic insulator to which a coating of metal powder is directly applied.

(5959) U. S. 2,368,746 (1945). P. W. Crist and S. G. Johansson (Western Electric Co.), *Liquid Handling Apparatus.* The apparatus is used for circulating a liquid suspension of Ag powder, in which quartz for high frequency electrical parts may be dipped to form a coating.

(5960) U. S. 2,369,067 (1945). E. Mayer, *Mold.* A mold for air cooled ribbed cylinders has core plates of Fe borings and sand.

(5961) U. S. 2,370,330 (1945). K. Smith, *Photographic Process.* Finely ground Ag or coloring material is applied to an image on a photographic glass plate to produce a lasting image.

(5962) U. S. 2,372,867 (1945). T. Tognola (Bendix Aviation Corp.), *Spark Plug.* A spark plug has a ceramic insulating sleeve coated with a high heat resisting metal powder, such as Ni or W.

(5963) U. S. 2,374,331 (1945). G. B. Cooke (Crown Cork & Seal Co.), *Process of Aluminum Coating.* Finely divided mica is coated with Al in a sealed

evacuated chamber by subjecting the material to an atmosphere of vaporized Al, while the particles are suspended freely, and depositing the condensed Al particles onto the mica particle surfaces.

(5964) U. S. 2,381,734; 2,381,735 (1945). M. E. Gantz (Aluminum Co. of America), *Mold Chill.* 30-50 mesh Fe pellets are used in making green sand mold chills.

(5965) U. S. 2,383,704 (1945). K. H. Ballard (E. I. Du Pont De Nemours & Co.), *Decorating Dinnerware.* Powdered Au or Ag is used in a burnish preparation to decorate dinnerware of porcelain.

(5966) U. S. 2,389,419; 2,389,420 (1945). A. J. Deyrup and K. H. Ballard (E. I. Du Pont De Nemours & Co.), *Electrical Capacitors.* The capacitors have alternate ceramic and Ag powder layers, fired to form a unit structure.

(5967) U. S. 2,390,025 (1945). A. J. Deyrup and K. H. Ballard (E. I. Du Pont De Nemours & Co.), *Electrical Capacitors.* Powdered Ag layers are used alternately with layers of powdered dielectric vitreous emanel suspended in a vehicle.

(5968) Brit. 579,531 (1946). E. K. Cole, Ltd. and J. N. Evans, *Electrical Conduction Layer on the Vitreous Envelope of an Electron Discharge Tube.* Degreased "Cu-lac" powder, suspended in an acid solution of "Paralac", is sprayed on the tube and baked at 120° C. (250° F.) for 15 min., after which the tube is given a protective coating of lacquer plus fine Al powder.

(5969) French 918,141 (1946). S. A. Brown Boveri & Co., *Gas Turbine Blade from Sintered Metal and Ceramic Material.* Blades are built up from layers of a graded mixture of metal powders and powdered oxides. An alternative method is to coat the cast blade with a mixture of Cr powder and a ceramic material, such as BeO, Al_2O_3, ZrO_2, porcelain, steatite or glass.

(5970) U. S. 2,392,353 (1946). R. B. Aitchison (Linde Air Products Co.), *Flux Forming Fuel.* Pulverized Fe is used in a flux forming fuel mixture to produce holes in concrete, rock, or other fusible minerals.

(5971) U. S. 2,392,429 (1946). R. A. Sykes (Bell Telephone Laboratories), *Piezoelectric Crystal.* An electrode film is formed on a piezoelectric crystal by using powdered metals.

(5972) U. S. 2,392,732 (1946). H. L. Gerhart (Pittsburgh Glass Co.), *Coating Material.* Al powder is used in a metal coating composition for glass.

(5973) U. S. 2,394,843 (1946). G. B. Cooke and F. J. Gavin (Crown Cork & Seal Co.), *Coating Material and Composition.* A method of making Al coated mica particles comprises mixing mica particles with Al powder and subjecting the mixture to an impact force by a movable element to wipe the mica on its surfaces with Al and thus coat it.

(5974) U. S. 2,359,442 (1946). K. H. Ballard (E. I. Du Pont de Nemours & Co.), *Electrical Capacitor.* Ag powders are used in making electrical capacitors, by coating sheets of a vitreous material with layers of a suspension of Ag, but leaving a portion of the sheet uncoated.

(5975) U. S. 2,397,623 (1946). T. S. Reese, *Film Applied to Glass.* Cu or Al powder is used in making an opaque film to be applied to glass.

(5976) U. S. 2,398,176 (1946). A. J. Deyrup (E. I. Du Pont de Nemours & Co.), *Electrical Capacitor.* An electrode layer of Ag powder in a ceramic bonding agent is applied to a ceramic base and coated with powdered vitreous glaze, then fired and provided with a second electrode by application of another layer of Ag. Slots are provided in the Ag layer to which a wire is hooked and held in place by a paste containing powdered Ag.

(5977) U. S. 2,399,313 (1946). K. H. Ballard (E. I. Du Pont de Nemours & Co.), *Electrical Capacitor.* Powdered Ag is used for electrical capacitors by building up on a temporary base a number of alternate layers of powdered vitreous enamel and Ag, removing the incomplete capacitor from the base, and transferring to a second base to fire the resulting structure.

(5978) Brit. 584,146 (1947). M. Hauser, *Metal-Containing Ceramic Articles.* A mixture of clay and metal powder or oxide powder is used for electrical heating devices.

(5979) Brit. 595,007 (1947). H. H. Hausner, *Composite Article of Metal and Ceramics.* The article consists of two layers, one a metallic mixture composed of 70% W, 20% Cu, 10% Ni, or 74% Fe, 25% Mo, 1% Cu; and a ceramic mixture composed of 90% talc, 10% feldspar.

(5980) Swiss 243,394 (1947). M. Hauser, *Production of Metal-Ceramic Bodies.* Hydrated silicate powder is mixed with metal oxide; the water is removed by heating to produce a porous body which then is sintered.

(5981) U. S. 2,415,036 (1947). A. C. Quinn (Bendix Aviation Corp.), *Electrical Resistant Material.* The material consists of a mixture of 50% powdered glass, 40% powdered Cu and 10% Si.

(5982) U. S. 2,428,785 (1947). L. H. Colvin, *Cement Composition.* A waterproofing composition is produced by heating a mixture of chromic acid and pumicite until it becomes black, reducing the black mixture to powder, mixing it with Al and reducing the mixture by heating.

(5983) U. S. 2,431,660 (1947). A. Gaudenzi (Brown, Boveri & Co.), *Turbine Blade.* The blade comprises a metal foot portion for attachment to a ring, and a working portion carried by the foot portion; the working portion is a fritted mixture of metal and ceramic powders, the metal content decreasing as the distance from the foot portion increases.

(5984) Brit. 601,738 (1948). Soc. D'Électricité De Paris, *Refractory Mastic for Assembly of Metallic Parts.* A refractory cement for the water walls in a Bailey pulverized fuel-fired furnace is made from a 1:2:3 mixture of cast Fe powder, ground refractory brick and carborundum wetted by dilute Na_2SiO_3.

(5985) Brit. Appl. 6275/48; 6276/48 (1948). The Kreidl Chemico-Physical Co., *Flake for Protective Coating.* Mica particles are coated with Al by vapor condensation, and may be colored by placing paraffin oil into the condensing chamber, or by operating the W filament used in the apparatus as a heat source with an excessively high voltage. A short length of Al wire is hooked over the W filament, and the particles are poured gently by vibration through the chamber. Other metals, *e.g.*, Cu, brass, bronze, are suitable as coating materials.

(5986) Brit. Appl. 24,681/48 (1948). Metallizing Engineering Co. Ltd., *Application of Sprayed Metal Coatings.* The invention is related to the spraying of Mo or Mo alloy wire to surfaces of ceramic or glass, but mentions also plastic wire incorporated with metal powders.

(5987) U. S. 2,437,559 (1948). D. H. Rowland(Porcelain Insulator Corp.), *Insulator.* An insulator is formed from a mixture of 26% ball clay, 20% flint, 32% feldspar, 22% china clay, and 1% Al powder.

(5988) U. S. 2,438,451 (1948). J. J. Owen (Standard Oil Development Co.), *Activation of Clay.* Clay is treated with an acid in excess of that required to remove the impurities, utilizing the excess for a reaction with powdered Al or Zn to generate H_2 during the treatment.

(5989) U. S. 2,450,532 (1948). T. Tognola (Bendix Aviation Corp.), *Insulation.* The material is produced by mixing powdered ceramics with metal powder and dampening the powdered mixture, placing the powder in different portions of a mold, compressing and backing until the mass is dried.

(5990) U. S. 2,454,270 (1948). R. K. Braunsdorff (Tung-Sol Lamp Works Inc.), *Basing Electric Bulbs.* The process comprises applying a ceramic material with a metallic filler on that part of the bulb blank to which the base is to be applied, sealing and applying a metal surface to the ceramic material, and then securing the base to the bulb.

(5991) Brit. 620,904 (1949). The Rauland Corp., *Layers of Finely Divided Particles.* Mosaic electrodes for television are made by screening a mixture of glass powder and a luminescent or metal powder onto a refractory base by the silk screen process used in printing.

(5992) Brit. 623,479 (1949). Johnson, Matthey & Co. Ltd., F. E. Kerridge and E. R. Box, *Decoration of Heat-Resisting Bases.* Ag transfers upon glass, pottery or china are obtained by applying a suspension of Ag and Pb borosilicate flux in an organic medium by the silk-screen printing method.

(5993) Brit. 627,678 (1949). Foundry Services Ltd., K. Strauss and R. Boddey, *Heat-Producing Mixture Containing Aluminum.* A mixture used for maintaining runners or risers at temperature for a given time during the cooling of castings consists of Al powder, an oxidizing agent, a fluoride and a refractory material.

(5994) Brit. 628,504 (1949). Johnson, Matthey & Co. Ltd., F. E. Kerridge and C. S. Couper, *Decoration of Glass and China.* Au transfers are obtained by a silk-screen printing paste consisting of 26% Au powder, 22% Hg aurate, 1% Pb borosilicate flux and 51% plasticized nitrocellulose.

(5995) Brit. Appl. 20346/49 (1949). Office National D'Études et de Récherches Aeronautiques, *Metal-Ceramic Material.* The material, suitable for heat engine elements and cutting tools, consists of 69.7% Al_2O_3, 0.3% Cr_2O_3, 18% Fe, 3% Ni, 6% Cr, and 3% Mo, or 50% Al_2O_3, 0.8% Cr_2O_3, and 49.2% Cr; the compacting pressure is 12 tsi and the sintering temperature 1700° C. (3090° F.).

(5996) French 946,870 (1949). M. A. Sertillange, *Metallized Concrete.* Precast blocks of concrete may be metal-sprayed with Zn, Cu, or Al to improve the mechanical strength under fluctuating temperatures.

(5997) U. S. 2,460,334 (1949). M. J. Buerger and E. Washken (Owens-Illinois Glass Co.), *Process of Making Bonded Structures.* Products consisting of metal and non-metallic mineral compounds which are characterized by being tightly bonded together, are composed of a metal, such as Cu; the finely powdered non-metallic compounds may be CaF_2, MgO, etc.

(5998) U. S. 2,461,878 (1949). C. J. Christensen, M. D. Rigtering and A. W. Treptow (Bell Telephone Laboratories), *Metallizing Composition.* A method of fastening electric leads to a quartz crystal comprises forming on the surface of the crystal a layer containing a finely divided metal (*e.g.*, Ag) and a finely divided glass flux and heating the layer to a temperature above the melting point of the flux for a time to fuse it and cause it to bind the metal particles together and to the surface.

(5999) U. S. 2,463,561 (1949). J. M. Riley, *Composition for Patching Metallic Bodies.* A waterproof cement for repairing metallic and non-metallic articles consists of a mixture of plaster of Paris, Portland cement, powdered Pb_3O_4, powdered alum, and rust-proofed steel particles.

(6000) U. S. 2,464,141 (1949). M. S. Maier (Eastman Kodak Co.), *Mirror with Low Thermal Expansion Support.* A mirror structure has a base of a powdered alloy containing 54% Co, 36.5% Fe and 9.5% Cr, with a layer of glass bonded to it and over-coated with a reflecting metal surface. The structure has substantially no dimensional change over wide temperature ranges.

(6001) U. S. 2,467,046 (1949). V. J. Mincieli, *Method of Metal Spraying Plaster of Paris Articles.* A decorative article, such as a bookend, lamp base or the like, is made by forming the article of plaster of Paris, dipping the body into an aqueous solution of $CaCO_3$ at spaced intervals, drying the body and coating portions of it with a metallic spray.

(6002) U. S. 2,467,144 (1949). J. M. Mochel (Corning Glass Works), *Electrically Conducting Refractory Body.* A ceramic refractory composition inert to molten glass and a good conductor of electricity at glass melting temperature is obtained by lowering the electrical resistance of known ceramic refractory bodies. This is accomplished by incorporating into SnO_2 a shrinking agent comprising a compound of Cu, Ag, Au, Mn, Fe, Co or Ni.

(6003) U. S. 2,467,528 (1949). M. Hauser, *Manufacture of Shaped Metal-Containing Ceramic Articles.* Metallic articles and metal-containing ceramics may be manufactured by methods used in the ceramic industry. The dried, shaped articles are fired in an atmosphere free of O_2 to prevent oxidation. The powdered raw materials which can be used include metals that can be liberated from their oxides by the aid of H_2.

(6004) U. S. 2,472,206 (1949). L. E. Greene, *Cementitious Refractory and Method of Making.* A high temperature refractory cement composition consists of ground fire clay, Fe filings, silica sand, salt and nitre cake.

(6005) U. S. 2,472,714 (1949). F. Massa, *Piezoelectric Sound Pressure Microphone.* When assembling crystal plates, a cement loaded with a metallic powder is used to increase the conductivity.

(6006) U. S. 2,473,526 (1949). A. Hood, *Slip Ring.* An Ag compound, containing elements of ceramic, is painted in channels of the slip ring and then fired to form a metallized surface.

(6007) U. S. 2,478,259 (1949). H. R. Feichter (U. S. Quarry Tile Co.), *Spark Plug Construction.* A portion of the spark plug can be made of conducting material, such as a sintered combination of ceramic material and a metallic powder, *e.g.*, Fe, Ni, Cr or W.

(6008) U. S. 2,480,473; 2,480,474; 2,480,475 (1949). A. F. Johnson (Reynolds Metals Co.), *Refractory and Method of Making It.* The vessel is made by dry mixing pulverulent Al, C and a binder, such as CaF_2 and cryolite. The mixture may be rammed between fused dense vitreous Al_2O_3 bricks of a cell and a plywood form and heated. Al may be produced by an electrolytic process, the method featuring several reduction stages in a single cell. In U. S. 2,480,475, a refractory composed of AlN, Al_2O_3, ZrO_2 and SiO_2, has utility in the electrolytic reduction of Al in cryolite fusions of Al_2O_3.

ii. Addition Agents and Coatings for Lubricants, Oils, Waxes, Soaps, etc.

(6009) U. S. 1,441,951 (1923). D. Sternlieb, *Packing for Stuffing Boxes.* A plastic packing composition consists of a mixture of oil, chalk, flaky graphite and spongy grains of metal, such as Pb and Sb alloy.

(6010) German 513,818 (1930). H. Vohrer, *Production of Soap Powder.* Alkaline soap is mixed with enough Al powder to form a voluminous mass which is easily pulverized.

(6011) U. S. 1,827,714 (1931). J. C. Morrell (Universal Oil Products Co.), *Dehydration of Emulsified Oil.* The dehydration is accomplished by suspending in the emulsion finely divided metal to improve the conductivity; the emulsion is then subjected to electric current to separate the oil and water.

(6012) Canadian 322,570 (1932). R. H. Churchill, *Leak-Sealing Material.* The material consists of finely divided oil-free oxidizable metal, carrying a protective coating of soap.

(6013) German 549,155 (1932). K. Jungmann, *Production of Floatable Soap.* The process includes addition of metal powders, *e.g.* Al or Mg, which evolve H_2 on contact with the alkali of the soap.

(6014) U. S. 1,891,506 (1932). N. Sommers and A. P. Karr, *Repair Leak Compound.* The compound consists of flaxseed meal mixed with Al powder, casein, and Na_2SiO_3.

(6015) German 570,876 (1933). Benzol-Verband G.m.b.H., *Method of Desulphurization of Oils.* The oils are treated with metal powder, *e.g.* Sn, Al, Cu, Mg, as a reducing agent, and with a solution of alkali compounds of these metals or their metal salts, which can bind the H_2S.

(6016) German 584,445 (1933). Electro Metallurgical Co., *Lubrication for Drawing Dies.* The lubricant consists of Al powder mixed with an agglutinant.

(6017) U. S. 1,923,058 (1933). H. R. Lowstuter, *Method of Treating Metals.* In a method of drawing tubes, a varnish low in C, having Al powder suspended therein, is applied to the inner and outer surfaces to act as a lubricant.

(6018) U. S. 1,933,907 (1933). L. C. Hickok, *Dental Wax.* Beeswax is mixed with 1% of impalpable Al powder.

(6019) U. S. 1,968,269 (1934). R. A. Swenson (Standard Oil Co.), *Dipped Candle.* A metallic coating composition for candles comprises a mixture of metal powders with a solution of solvent and ester gum.

(6020) U. S. 1,980,016 (1934). W. R. Thurston, *Brake Dressing.* The dressing comprises a mixture of Zn, Pb, Sn, talc and a binder of oil, wool grease, solution of rubber and resin.

(6021) U. S. 1,991,395 (1935). C. Kocour, *Process for Treating Metal.* The process comprises deforming the metal in a die in the presence of a mineral lubricant containing Al dust, which preserves the metal as a protective agent, and subjecting the coated metal to a cleaning bath.

(6022) U. S. 2,211,373 (1940). B. Folda, Jr. (Socony-Vacuum Oil Co.), *Zinc Dust Lubricant Suitable for Use on Well-Casing Threads.* A thread lubricant consists of a cup of grease and Zn dust, rendered chemically stable by the addition of a free fatty substance in an amount sufficient to neutralize free alkaline ingredients.

(6023) U. S. 2,298,908 (1942). C. Wentworth (Radio Corp. of America), *Paramagnetic Particles.* Spongy metal particles are coated or soaked with motor oil and compressed.

(6024) U. S. 2,302,703 (1942). B. H. Lincoln, *Lubricant.* Zn dust is utilized in a lubricant as a thickening ingredient.

(6025) U. S. 2,316,778 (1943). J. J. Fiechter, *Packing.* A self-lubricating metallic packing comprises metal flakes coated with graphite, using foundry molasses as a binder.

(6026) U. S. 2,322,438 (1943). R. W. Henry, *Lubricant.* Dewaxing lubricant stocks consist of cold, immiscible metal powders in a solution of waxy oil in a dewaxing solvent.

(6027) U. S. 2,326,938 (1943). E. W. Fuller and L. A. Hamilton (Socony Vacuum Oil Co.), *Mineral Oil Composition.* Mineral oil containing Fe granules is used as a lubricant.

(6028) U. S. 2,334,738 (1943). J. Wulff, *Lubricants.* About 0.1% or more of Bi in flake form is dispersed in an oil, such as paraffinic or naphthenic oil to form lubricants, suitable for use under high pressures, as in engines and cutting operations.

(6029) U. S. 2,339,371 (1944). S. B. Becker (Standard Oil Co.), *Lubricant.* An oil mixed with sulfurized halogenated phosphate material may include Fe particles as halogen carrier.

(6030) U. S. 2,345,239 (1944). E. W. Cook and P. H. Moss (American Cyanamid Co.), *Lubricant.* The lubricant utilizes metal salts prepared by treating a free amino compound with powdered Al.

(6031) U. S. 2,350,783; 2,353,169 (1944). B. H. Lincoln (Socony Vacuum Oil Co.), *Lubricant.* Oil is incorporated with metal salts or metal powders, such as Cu, as treating agent.

(6032) U. S. 2,356,661 (1944). F. B. Downing (E. I. Du Pont De Nemours & Co.), *Lubricant.* Lubricating oil is mixed with Cu powder.

(6033) U. S. 2,361,018 (1944). H. L. Gerhart (Pittsburgh Plate Glass Co.), *Artificial Drying Oil.* The oil may be combined with metallic pigments to produce a liquid film which will harden to a firm state.

(6034) U. S. 2,372,773 (1945). J. J. Fiechter, *Packing.* A self lubricating semimetallic packing is composed of a number of interlocked pellets of lubricant coated with soft metal.

(6035) U. S. 2,378,820 (1945). E. Arnott (Union Oil Co.), *Lubricant.* Oil is mixed with Zn or ZnO powder.

(6036) U. S. 2,380,126 (1945). F. A. Sturm, *Marking Crayon.* The crayon consists of bronze powder mixed with resin, wax and paraffin.

(6037) U. S. 2,380,454 (1945). B. H. Lincoln (Socony Vacuum Co.), *Lubricant.* Zn dust is added to a lubricating oil.

(6038) U. S. 2,383,148 (1945). J. D. Morgan (Cities Service Oil Co.), *Lubricant.* Finely divided Pb is incorporated in lubricant grease.

(6039) U. S. 2,383,990 (1945). S. Quisling, *Cosmetics.* Bronze and Al powders are added as coloring agents to cosmetics.

(6040) U. S. 2,388,299 (1945). R. H. Thielemann (General Electric Co.), *Method of Fabricating Molds.* A fusible mold pattern, *e.g.*, wax, is coated with

a mixture of finely divided refractory metal and organic binder; further processing consists of drying the coating, contacting it with a composition of an organo-Si halide and thereafter embedding the coated pattern into an investment composition of refractory metal with an aqueous solution of binder.

(6041) U. S. 2,392,468 (1946). H. Engelke (Cities Service Oil Co.), *Lubricant Additive.* Powdered Ag is used in a phosphite ester as a lubricant.

(6042) U. S. 2,397,767 (1946). J. E. Taylor (Procter & Gamble Co.), *Copper Soaps.* Powdered Cu is used in making Cu soap.

(6043) U. S. 2,427,398 (1947). W. C. Ferguson and P. Sussenbach (Presstite Engineering Co.), *Heat-Conductive Luting Material.* The material consists of 25% graphite, 25% vehicle of soft petroleum resin and asphalt, 50% Al filings.

(6044) French 936,562; 936,563 (1948). G. Duyck, *Electromagnetic Clutches.* To obtain smoother starting, the electromagnet is given a facing of sintered Fe-graphite, the graphite acting as a lubricant, in addition to the self-lubricating effect of the porous material.

(6045) U. S. 2,434,113 (1948). H. W. F. Lorenz, *Selective Adsorption of Lubricants.* A method of extracting oiliness agents from lubricant oil comprises wetting metal particles having a melting point below 200° C. (390° F.) with the oil to impregnate and coat the surface, separating the unattached oil, melting the metal to set free the oiliness agent, and recovering it by gravity separation.

(6046) U. S. 2,462,018 (1949). W. H. Wood (Harris-Seybold-Potter Co.), *X-Ray Opaque Marking Means.* The pencil is made of a material in fine particle size having metal atoms of high atomic weight in a carrier or vehicle substance; 50% colloidal Pb and a water-soluble polymerized aliphatic material of wax consistency, such as cerecine, paraffin, or stearine waxes is claimed.

(6047) U. S. 2,485,019 (1949). P. P. Somerville (Jones & Laughlin Steel Corp.), *Lubricated Wire Rope.* The rope is made up of strands wound together and a lubricant comprising an oleaginous carrier containing powdered bearing metal, such as bronze, Zn or Al, which covers the strands to lubricate them and to externally lubricate the rope.

(6048) U. S. 2,486,130 (1949). R. L. Dietrich and R. W. Williams (The Dow Chemical Co.), *Lubricant Composition.* The composition consists of 50 to 70 parts Al powder having a mesh size of 120 to 400; 20 to 30 parts metallic soap, such as the palmitate and stearate of K or Na, and 10 to 20 parts of hydrogenated cottonseed, lard, or peanut oil. The lubricant is useful for working into shape objects of Mg and Mg base alloys.

iii. Addition Agents and Coatings for Asbestos, Rubber, Leather, Fabric, Cloth, Paper, Cellulose, Wood, Cork, etc.

(6049) U. S. 44,944 (1864). A. Erhard, *Flaking Cloth on Paper.* Silk or other fiber flock is applied to varnished paper with bronze, German metal and steel powders.

(6050) U. S. 52,673 (1866). M. W. Brown, *Process for Ornamenting Surfaces.* For coating wood, paper or glass, alkaline silicate is used as an undercoat over which metal powders are applied.

(6051) U. S. 59,281 (1866). T. B. Shaffner, *Manufacture of Paper.* In the manufacture of paper for bank notes, metal powder is added to the pulp.

(6052) U. S. 72,601 (1867). R. Noggerath, *Coating and Metallizing Fabrics.* Fabrics are metallized with metal powders to give the appearance of open-work metal.

(6053) U. S. 89,274 (1869). J. B. Batchelder, *Surfacing Fabrics with Bronze.* In surfacing fabrics with bronze or other metal powders, the powder is applied over size and the coated fabric is calendered.

(6054) U. S. 122,636 (1872). T. H. Mueller and J. Reckendorfer, *Stamping Varnished Surfaces.* The process comprises dipping a varnished pencil in bronze powder and then stamping the bronze coated surface with a heated die.

(6055) U. S. 190,477 (1877). B. Dreyfuss and S. Sachs, *Finishing Cardboard.* Cardboard is finished for perforation by calendering cardboard coated with a mixture of finely divided Zn, glue, starch and wax.

(6056) U. S. 209,625 (1878). R. E. Peterson and E. J. Frost, *Process of Bronzing a Paper.* Sized paper is bronzed in a chamber where bronze powder is kept circulating.

(6057) U. S. 215,222 (1879). J. C. Hofer, *Process of Gilding Moldings.* A molding is gilded by coating it with whiting, Au size, starch size and bronze dust.

(6058) U. S. 226,497 (1880). R. Cunningham, *Process of Manufacturing Articles in Imitation of Papier-Mache.* To coat hard rubber, ivory, or glass, metal powder is applied over a varnish coat and given over-coats of varnish and collodion.

(6059) U. S. 229,427 (1880). N. C. Laurense and E. G. Matzka, *Gilding Process.* Gilding and bronzing powders are applied to moldings by brushing on in liquid form.

(6060) U. S. 245,328 (1881). J. H. Tuttle, *Process of Making Sheet Packing.* Sheet packing of rubber or paper is covered with adhesive and a layer of brass or Fe filings and then calendered.

(6061) U. S. 252,383 (1882). P. Juel (Schuetz & Juel), *Treating Textile Fabrics.* Metallic textile fabrics comprise a textile base and a burnished coating of metal powders and caoutchouc.

(6062) U. S. 274,594 (1883). J. Hartnagel and J. N. Wiggin, *Window Shades.* Window shades are sized and coated with metal powders.

(6063) U. S. 278,206 (1883). N. S. White, *Surface Coating for Leather or Rubber.* Leather or rubber is first coated with guttapercha or rubber adhesive, then with bronze powder.

(6064) U. S. 304,069 (1884). L. Brown (L. N. White), *Metallizing Wood.* Wood is metallized by applying Zn in the plastic state.

(6065) U. S. 321,234 (1884). M. B. Martin, *Process of Staining Paper.* Colored or bronze surfaces are produced on paper by applying color in a wash and absorbing the surplus color.

(6066) U. S. 335,725 (1885). S. E. Trout (H. S. Wendel), *Manufacture of Wall Paper.* In the manufacture of wall paper, Na_2SiO_3 and bronze powder are employed.

(6067) U. S. 369,839 (1887). H. Storey and I. H. Storey, *Manufacture of Oil Cloths.* To design-coat oilcloth, a pattern is printed in cement and metal powder is dusted over it.

(6068) U. S. 380,515 (1887). J. C. Pennington, *Wrapping paper.* Powdered Zn is incorporated in wrapping paper for metallic articles to prevent rusting.

(6069) U. S. 509,280 (1893). T. M. Ash and H. W. Gill, *Coating Non-Metallic Articles.* Paper or wood are metal plated by first coating with a varnish carrying powdered metal, and then immersing in $AgNO_3$ from which Ag precipitates in a film.

(6070) U. S. 522,766 (1894). J. W. Peele, *Packings for Stuffing Boxes.* A process of making packings consists of immersing a dry packing of fibrous material in a bath of lubricant, removing it, and drying and coating it with Al powder.

(6071) U. S. 569,759 (1896). R. H. Martin, *Composition of Matter.* A composition, to be used in journal boxes and bearings generally, comprises small particles of metal and asbestos fiber, consolidated by pressure.

(6072) U. S. 629,427 (1899). G. D. Coleman, *Coating for Wood.* Wood exposed to sea water is coated with powdered Cu; the Cu particles are embedded in the wood by driving them mechanically into indentations cut into the surface of the wood.

(6073) U. S. 741,227; 741,228 (1903). G. D. Coleman (Coleman Ship Coppering Co.), *Antifouling Coating.* A coating for ship bottoms of wood consists of varnish and paint over which Cu is blown and hammered in.

(6074) U. S. 819,125 (1906). G. D. Coleman, *Antifouling Coating.* A coating for ship bottoms, in particular those made of wood, consists of alternate layers of paint and powdered Cu blown onto the paint coating while it is still moist.

(6075) U. S. 995,289 (1911). F. A. Price, *Coating Metallic Surfaces.* Cloth for theatre curtain is given a metallized coating by suitable under-coats and a surface of Al and ultramarine blue powder.

(6076) U. S. 1,031,616 (1912). P. Benrath, E. Damm and O. Stephani (Farbenfabriken vorm. Bayer & Co.), *Lustrous Thread.* Threads having a metallic luster are produced by passing them through a mixture of metallic bronzes or powders with a solution of cellulose acetate.

(6077) U. S. 1,047,867 (1912). F. Wickel, *Manufacture of Metal-Foil Paper.* Metal foil paper for hot-embossing is made by coating a tissue with melted carnauba wax and applying bronze powder.

(6078) U. S. 1,060,098 (1913). B. Kaufmann, *Manufacture of Metallic Paper.* Metallic paper is manufactured by applying to waterproof paper with an engraved roller a paste of metal powder and an adhesive liquid, such as shellac.

(6079) U. S. 1,082,123 (1913). S. H. Jones, *Moving Picture Screen.* An oilcloth base is softened, coated, and metal powder is rubbed into the coating.

(6080) U. S. 1,149,940 (1915). H. Pannill, *Moving Picture Screen.* Canvas is coated with linseed oil and a japan drier, and Al or Au powder is rubbed into the coating.

(6081) U. S. 1,158,770 (1915). A. J. Bailey, *Packing.* A packing composition comprises pulverized metal mixed with a mineral lubricant, fat, fibrous material and powdered cork.

(6082) U. S. 1,223,399 (1917). W. G. Koch, *Metal-Coated Paper Sheet.* The process comprises the application to the paper of a varnish-proof coating, a tacky varnish and finally powdered metal.

(6083) U. S. 1,266,778 (1918). T. A. Edison (Edison Storage Battery Co.), *Projection Screen.* Oilcloth is heated until it is tacky and then powdered Al is rubbed on.

(6084) U. S. 1,281,374 (1918). H. E. Honeywell, *Varnishing Balloons.* Cloth is varnished and a mixture of Al powder and French chalk is rubbed in.

(6085) U. S. 1,282,014 (1918). M. Kruemmling, *Coating.* Mouthpieces for cigarettes are made by squirting a coating of a liquid mixture of metal powders at intervals on a web of cigarette paper.

(6086) U. S. 1,320,950 (1919). W. Willmott, *Art of Stamping Book Covers.* A die face used for stamping book covers is greased and metal powder is applied to the die; the die is then impressed on the thermoplastic coating on the book.

(6087) U. S. 1,376,961 (1921). W. H. Meade and S. H. Friestedt, *Finishing the Surface of Grain-Leather.* Coloring and finishing the surface of grain-leather includes coating it with a metal precipitated from a soluble compound.

(6088) U. S. 1,385,184 (1921). W. H. Meade and S. H. Friestedt, *Method of Finishing Leather.* Leather is finished with a coating including Se powder.

(6089) U. S. 1,465,107 (1923). K. Wickel, *Metal-Coated Paper.* The surface of a metal coated paper consists of metal powder and a binder of a bituminous substance.

(6090) U. S. 1,481,610 (1924). F. Koperski and J. A. Pacynsky, *Process for Finishing Wood.* Wood is finished by applying to it a mixture of metal dust and varnish.

(6091) U. S. 1,510,654 (1924). L. J. Cavanaugh, *Ornamenting Fabrics.* Ornamenting and soil-proofing fabrics comprises applying a liquid carrier or binding medium containing metal powders to impregnated fabrics.

(6092) U. S. 1,521,055 (1924). T. F. Tesse (Soc. Nauton Frères & De Marsac), *Coated Aeroplane Cloth.* Aeroplane cloth is coated with a flexible coating containing metal powders enclosed between two layers of rigid cellulose ester.

(6093) U. S. 1,557,530 (1925). P. J. Martin, *Preparation of Metallic Screens.* Metallic screens for luminous projections are produced by applying a coating of Au and Al powders to fabrics.

(6094) U. S. 1,572,180 (1926). G. E. Buzza, *Greeting Cards*. Parchment is heated, printed, and dusted with bronze powder.

(6095) U. S. 1,590,399 (1926). J. Tykocinski-Tykociner, *Sound Motion Picture Film*. The hygroscopic character of a film is varied in accordance with the image, and the wet film is dusted with magnetic metal powders.

(6096) Brit. 263,761 (1927). H. Strobl, *Balloon Coverings*. Al powder is used as a coating for fabrics to prevent stickiness.

(6097) U. S. 1,614,611 (1927). G. E. Grimm (Westfield River Paper Co.), *Coating Paper*. A coating for paper is made by mixing metal powders with shellac and a waxy substance.

(6098) U. S. 1,617,946 (1927). G. E. Grimm (Westfield River Paper Co.), *Metal Coated Paper*. Tinned, burnished, and metal-coated paper is made by employing metal powders, a hard resin, a soft gum, and a dry wax.

(6099) U. S. 1,647,055 (1927). T. Richards, *Rubber Glove*. A glove for X-ray operators is made by laminating a powdered metallic Pb and dipped rubber composition.

(6100) U. S. 1,653,467 (1927). J. A. O'Neill, *Sound Film of Paper*. The paper has a trail of magnetic metal dust in a binder locally polarized under the magnetic needle in a recorder circuit.

(6101) Brit. 300,060 (1928). W. I. Einstein, *Organic Article with Metallic Layer*. The article is dipped in soluble glass; after drying, the surface is sanded and then metallized by a gun with an easily fusible alloy of metals, such as Pb, Sn, Zn, and then with a second layer of Cu or bronze powder.

(6102) Brit. 306,129 (1929). H. Beckmann, *Porous Body*. Porous rubber is mixed with C, silica gel and metal powder.

(6103) German 472,714 (1929). H. Glootz, *Metallic Paper*. Metallic powder is strewn on a paper band covered with glue; the paper band is then rolled up and pressed to unite the metallic surface with the paper.

(6104) Swedish 74,719 (1929). K. J. T. Ohlsson, *Manufacture of Rubber or Balata with Closed Pores*. Al granules in conjunction with dilute acids or alkalies and water serve as a pore-forming agent; the rubber is vulcanized by heating in air.

(6105) U. S. 1,749,474 (1930). J. D. Edwards (Aluminum Co. of America), *Balloon Envelope*. The envelope consists of a gas-retaining coating of rubber with flake-like metallic particles throughout a portion of its thickness.

(6106) U. S. 1,790,615 (1931). F. Neuber and R. Nowak (O. Trebitsch), *Manufacture of Metallized Fibrous Material*. Fibrous materials are metallized by precipitating on the material metal obtained by reduction from a metallic salt solution.

(6107) U. S. 1,825,252 (1931). B. S. Taylor (B. F. Goodrich Co.), *Decorating Rubber*. Rubber hot water bottles or shower curtains are decorated with metal powder dusted over an adhesive; the powder may be coated with an organic dye.

(6108) U. S. 1,832,199 (1931). J. E. George (Alligator Co.), *Process for Ornamenting Surfaces*. A frosted effect is produced by impregnating woven fabrics with a liquid composition including metal powders and wood oil.

(6109) U. S. 1,833,317 (1931). J. Crawford, *Projection Screens*. Fabric is prime coated and Al powder and mica is dusted on and varnished over.

(6110) Danish 46,733 (1932). Cellegummi A. S., *Manufacture of Rubber or Balata with Closed Pores*. *Cf.:* Swedish 74,719 (No. 6104).

(6111) U. S. 1,847,860 (1932). F. M. Best, *Sound Recording*. A phonograph record or sound film is coated with colloidal magnetizable Fe in a binder, and a light sensitive emulsion is sprayed over the binder.

(6112) U. S. 1,877,394 (1932). J. E. George (Alligator Co.), *Treating Fabrics*. The treatment of fabrics comprises passing them through a liquid bath containing a metallic pigment, such as Al powder, and then passing them through rolls.

(6113) U. S. 1,883,559; 1,883,562 (1932). H. E. Chipman (A. L. Chipman Corp.), *Sound Film*. Granular magnetic material is pocketed between the celluloid film and a coating of glue or cement-like material.

(6114) U. S. 1,885,344 (1932). R. J. Griffiths (B. F. Goodrich Co.), *Fountain Pen Sac.* A fountain pen sac is coated with Al powder.

(6115) U. S. 1,912,887 (1933). H. E. Chipman (A. L. Chipman Corp.), *Sound Film.* A cement-like layer on top of celluloid film has deposited on it a line of magnetic, connected metal particles, coated over with cementitious substances.

(6116) U. S. 1,924,803 (1933). M. E. Paradise (Grigsgy-Grunow Co.), *Loud Speaker.* The speaker contains an acoustic diaphragm of woven fabric having its interstices filled with a stiffening agent and having its surface covered with a mixture of metal powder and graphite in a binder.

(6117) U. S. 1,940,315 (1933). E. E. McKay (Revere Rubber Co.), *Rubber Article.* A colored lustre finish is applied to rubber articles by coating them with a mixture of Al powder and colored rubber ink.

(6118) Brit. 410,407 (1934). K. Bergstein, R. Peböck and W. Bartzik, *Production of Plated Non-Metallic Articles.* An electrically conductive layer of metal powder, which has a lower potential than Cu, is applied to a resinous article by a varnish, then the article is immersed in an acid Cu bath, which acts as a binding bath, without the use of electric current to deposit a layer of Cu on the article and prepare it for further plating with Cu.

(6119) Brit. 419,488 (1934). Siemens & Halske A. G., *Electric Cable.* The insulation is protected against light and heat rays by an external polished layer of varnish which contains Al powder.

(6120) French 758,048; 758,049 (1934). A. Bocage and J. E. Vispalie, *Surface Covering for Soil.* Raspings of cardboard are mixed with residues of felt and asbestos, Al_2O_3, and Cu powder.

(6121) French 767,561 (1934). I. G. Farbenindustrie A. G., *Metallized Paper.* Fe carbonyl metal powder is incorporated in the paper pulp before the production of the paper.

(6122) U. S. 1,942,763 (1934). W. R. Menshon (Barrett Co.), *Process for Making Felt.* Marking designs are produced on a fibrous material by applying a suspension of metal powders in a dilute silicate solution.

(6123) U. S. 1,949,840 (1934). J. E. Languepin (Radio Corp. of America), *Sound Record Strip.* The strip has a track of metal powder; a constant magnetic field is used for setting the powder as it is coated onto the celluloid strip.

(6124) U. S. 1,968,269 (1934). R. A. Swenson (Standard Oil Co., Inc.), *Dipped Candle.* The candle is furnished with a superficial coating of a mixture of metal powders and ester gums.

(6125) U. S. 1,979,031 (1934). J. Frisch, *Coating Dolls.* A dusting composition for rubber dolls contains powdered Mg and Al.

(6126) French 780,342 (1935). R. Reany, *Method for the Adherence of Caoutchouc to Metal.* The surface of the metal is coated with thermo-plastic caoutchouc and a binding layer of Al powder mixed with lampblack and Zn.

(6127) U. S. 1,998,890 (1935). J. M. Bandish, *Packing for Moving Parts.* The packing consists of a fabric element coated with a mixture of comminuted Al flakes and a lubricant.

(6128) U. S. 1,998,892 (1935). T. J. Braden, *Packing for Moving Parts.* The packing consists of a casing of knitted fabric containing a moldable mass of packing material with a coating of rubber cement and comminuted Al flakes.

(6129) U. S. 2,020,787 (1935). D. E. Knapp, *Screen.* A fabric screen is embossed into raised and depressed areas; the depressions carry a metallized coating to increase the diffusion of light.

(6130) U. S. 2,032,845 (1936). F. W. Humphner (Mid-States Gummed Paper Co.), *Adhesive Tape.* Adhesive tape has a metallic coating of powder, casein, clay and wax, and a pressure-sensitive coating on opposite sides of the web of paper. The coating powder consists of 15% Sn, 10% Pb, 10% casein, 15% clay, 1% wax, balance Ag.

(6131) U. S. 2,034,008 (1936). W. I. Taylor, *Artificial Threads.* Artificial threads are coated with metal powder simultaneous with their extrusion.

(6132) U. S. 2,035,475 (1936). D. L. Hay, *System of Recording.* In a recording process, where different colored line records are obtained on moving paper, the point electrode is tipped with colored powder mixed with magnetic Ni or Fe powder.

(6133) U. S. 2,041,297 (1936). R. S. Moore (Columbia Ribbon & Carbon Manufacturing Co.), *Coated Membrane.* A metallic coated membrane is produced by applying a coating containing metal powders and a resinous, fatty substance.

(6134) U. S. 2,041,480 (1936). H. Oexmann, *Magnetic Recorder.* Powdered carbonyl Fe or alloys are used as a coating on a nonmagnetic metal support of paper or cellulose.

(6135) U. S. 2,054,454 (1936). H. R. Thies and T. A. Riehl (Wingfoot Corp.), *Molded Product with Color Effect.* The process consists of milling between 0.1 and 1.0 parts of a metallic powder, *e.g.* Sn, into 100 parts of a rubber derivative and then splitting off the Sn from the resulting product to produce a thermoplastic material, a thin layer of which when molded will produce a transparent or translucent product.

(6136) U. S. 2,060,928 (1936). F. M. Dawitz (Irvington Varnish & Insulator Co.), *Cork Closures.* Cork closures for containers are coated with a shellac base dusted with metal powders.

(6137) U. S. 2,064,778 (1936). R. C. Bateman (Wingfoot Corp.), *Tire Mold.* The rubber matrix is metallized by spraying on it a coating of bronze or Cu in lacquer and subsequently dipping into an alkaline AgCN solution, to silver the surface and thus improve the metallization.

(6138) U. S. 2,083,441 (1937). F. H. Frost (S. D. Warren Co.), *Lacquer Coated Sheet Material for Paper.* Lacquer coated paper sheet material has a mineral coating containing metallic pigments and an adhesive dispersed in water.

(6139) U. S. 2,087,094 (1937). J. D. McBurney (E. I. du Pont de Nemours & Co.), *Metallic Finish.* A high metallic luster on fabrics is obtained by applying Al dust over a specific base coat, buffing and baking.

(6140) U. S. 2,101,518 (1937). H. T. Stewart, *Fibrous Material.* Fibrous material is coated with metal powders before weaving it into packing material.

(6141) U. S. 2,101,887 (1937). J. Allan and J. A. Wainwright (Celanese Corp. of America), *Production of Effects on Textiles.* Effects on textile materials are produced with Al powder in cellulose acetate solution.

(6142) U. S. 2,105,440 (1938). B. C. Miller (Bert C. Miller Inc.), *Metal Coated Paper.* A thin layer of Cu powder is deposited on a moving cathode and an adhesive coated paper is pressed against the metal layer on the cathode.

(6143) U. S. 2,108,339 (1938). M. P. Kirk and I. H. Grancell, *Bearing.* Bearings produced from raw rubber are evenly loaded with a composition of metallic Pb impregnated with castor oil.

(6144) U. S. 2,120,434 (1938). E. C. Clayton (William E. Hooper & Sons Co.), *Vehicle Top Cover.* A waterproof vehicle top cover is produced by treating fabric with liquid latex mixed with Al powder.

(6145) U. S. 2,125,341 (1938). C. B. Hall and J. D. McBurney (E. I. du Pont de Nemours & Co.), *Coated Fabrics.* A metallic finish for coated cellulose derivative fabrics is obtained by use of an acetate film, which is superimposed over metal powders.

(6146) U. S. 2,143,948 (1939). H. Karl, *Coating for Paper.* A coating that sticks to paper is made by applying a design with lacquer, dusting on a metal powder, fluxing, and fusing molten metal over the powder.

(6147) U. S. 2,211,583 (1940). S. Rubens, *Electric Condenser.* An electric condenser is produced by employing Cu bronze particles to coat a flexible organic sheet, and subjecting the coated sheet to the action of a reducing acid.

(6148) U. S. 2,252,776 (1941). D. W. Losee, *Film for Photogravure Printing.* The cellulose film is coated with Cu powder forming an etching surface.

(6149) U. S. 2,299,813 (1942). R. Franks (Electro Metallurgical Co.), *Gasket.* A gasket formed of rubber or asbestos has sealing surfaces of powdered low C ferro-Cr.

(6150) Canadian 438,748 (1943). Continental Can Co., Inc., *Aluminum Pouder and Resin Spot Facing Material.* Paper caps are coated with Al flake powder and a resin.

(6151) U. S. 2,313,379 (1943). R. E. Wood (Van Cleef Bros.), *Mounting Means for Electrical Units.* Mountings for electrically operated units incorporate powdered Al in sponge rubber.

(6152) U. S. 2,322,367 (1943). A. G. Kjellstrand (Interchemical Corp.), *Carbon Paper.* A coating for carbon paper contains Al powder to make the paper non-curling and slip-resistant.

(6153) U. S. 2,325,584 (1943). P. S. Barnhart (Westfield River Paper Co.), *Coated Laminated Paper.* Al powder is used for laminating two sheets of paper together.

(6154) U. S. 2,339,840 (1944). A. J. Daly and W. G. Lowe (Celanese Corp. of America), *Sheet Material.* Sheet material of cellulose acetate has metal powders incorporated in the dope from which intermediate layers are formed.

(6155) U. S. 2,341,461 (1944). J. C. Matthews and S. E. Sheppard (Eastman Kodak Co.), *Photographic Film.* The production comprises coating the side of a photographic film not carrying the emulsion layer, with finely divided Ag to prevent fungus growth.

(6156) U. S. 2,341,508 (1944). W. Schneider and N. Senger, *Sound Records.* The transparency difference of sound records in multilayer materials is increased by treating them with a solution capable of dissolving colloidal Ag but leaving granular Ag unattacked.

(6157) U. S. 2,341,509 (1944). R. S. Bley (North American Rayon Corp.), *Viscose Solution.* A viscose solution for viscose sponges contains Al powder.

(6158) U. S. 2,341,944 (1944). B. A. Olsen, *Tamping Wad.* Metal powders are used to overcome a natural buoyance of the body of fibrous material.

(6159) U. S. 2,343,658 (1944). W. M. Gearhart (Eastman Kodak Co.), *Thermoplastic Composition.* A thermoplastic decorative composition employs metal powders and resin particles as a coating.

(6160) U. S. 2,345,549 (1944). P. S. Christaldi, A. Steadman, and D. T. Wilber, (Allen B. Du Mont Laboratories Inc.), *Making Lasting Records.* Records of a material sensitive to light are produced by an emulsion of Zn-Cd sulfide mixed with Mn powder in gelatine and methyl cellulose to form a layer on a solid base of wood; the coating is then exposed to ultraviolet light in the presence of moisture.

(6161) U. S. 2,348,130 (1944). C. J. Hardy, *Armor Plating.* Projectile resistant armor plating comprises a layer of yieldable material, such as rubber, with pockets of hard Fe filings, between two layers of the armor plate.

(6162) U. S. 2,352,014 (1944). A. Rott, *Photomechanical Printing.* A process of photographic image transfer comprises contacting a photographic Ag halide layer containing a developing solution and a developed photographic image in the presence of an Ag halide solvent and a fogging agent, *e.g.* colloidal Ag, with a reception material insensitive to light, such as celluloid.

(6163) U. S. 2,354,018 (1944). H. Heltzer (Minnesota Mining & Mfg. Co.), *Light Reflector Sheet.* The sheet consists of water-resistant impregnated paper and has a backing sized with a coating including Al pigment for a reflecting surface.

(6164) U. S. 2,354,073 (1944). D. D. Swift, *Gold Leaf Sheet.* The sheet comprises a carrier strip of cellulose acetate with layers of adhesive material, metallic Au leaf and sizing thereon.

(6165) U. S. 2,355,430 (1944). W. H. Flood, *Traffic Guiding Stripe.* A traffic guiding stripe consists of an adhesive layer with a layer of metallic Sb embedded therein.

(6166) U. S. 2,355,902 (1944). C. T. Berg (Photoplating Co.), *Sign with Animated Effect.* An animated display device comprises a transparent sheet of celluloid having a photographically produced design, developed by rubbing thereon a metallic pigment, such as bronze powder.

(6167) U. S. 2,357,073 (1944). W. M. Billing (Hercules Powder Co.), *Adhesive Composition.* An adhesive composition used in the production of abrasive papers contains metal powders.

(6168) U. S. 2,362,884 (1944). J. W. Clark (S. D. Warren Co.), *Aluminum Coated Paper.* Al-coated paper is made by applying to a paper backed calendered mineral coating a layer of aqueous Al-containing composition and an adhesive, and calendering the dried coating.

(6169) U. S. 2,363,688 (1944). A. E. Pollard, *Packing.* The packing material comprises a mass of non-elastic metallic particles and oil-soaked wooden particles.

(6170) U. S. 2,367,152 (1945). H. Straeb, *Metallized Paper.* Metallized paper for the production of condensers is made by applying a metal coating on the paper already having an insulating coating.

(6171) U. S. 2,374,214 (1945). B. L. Kline and C. E. Mobius (Western Union Telegraph Co.), *Electrically Conducting Paper.* Al powder is incorporated in the paper pulp to make the paper conductive.

(6172) U. S. 2,375,766 (1945). C. W. Britcher (Craig Corp.), *Dry Spray Equipment.* The apparatus is used for spraying metal powders on paper in producing metallized paper.

(6173) U. S. 2,379,846 (1945). I. H. Wilsey and J. W. Meaker, *Perforating of Sheet Material.* Bronze powder is incorporated in lacquer coating for paper to facilitate perforating the paper by electrical discharges.

(6174) U. S. 2,381,205 (1945). R. A. Coughey (University of New Hampshire), *Molding Powder.* Metallic powders are used as fillers in moldable compositions made of treated ground wood.

(6175) U. S. 2,381,911 (1945). B. C. Kathe, *Electrodeposition.* Powdered Cu is deposited on an electrically nonconductive surface of rubber to produce a conductive film.

(6176) U. S. 2,382,065 (1945). H. Kappeler (Micafil Ltd. Works for Electric Insulation and Winding Machines), *Wound Condensers.* Metal powder is added to colloidal graphite and sprayed onto an insulation web to form a wound condenser.

(6177) U. S. 2,383,566; 2,383,567; 2,383,568 (1945). B. Rudnick (Republic Aviation Corp.), *Photomechanical Negative.* Powdered Al is used to prepare a layer on the negative of celluloid or plastic material.

(6178) U. S. 2,387,730 (1945). W. L. Alderson (E. I. du Pont de Nemours & Co.), *Cork-Like Product.* Powdered Ni or Fe is used in preparing cellular materials from ethylene polymers.

(6179) U. S. 2,389,469 (1945). F. J. Tone, L. Mahlman and F. Brown (Carborundum Co.), *Manufacture of Adhesive Tapes.* Powdered Al is used in making adhesives.

(6180) U. S. 2,389,641 (1945). D. V. Sarbach (B. F. Goodrich Co.), *Method of Adhering Rubbery Material to Smooth Surfaces.* A composite structure comprises a base member, a body of rubbery material secured to the base member by an intermediate bonding means consisting of finely divided metal as a primer coat and a second primer coat of finely divided hard material.

(6181) U. S. 2,389,682 (1945). W. Nebel (E. I. du Pont de Nemours & Co.), *Coating for Paper.* Metal powders are used in a composition for a protective or decorative coating for paper.

(6182) U. S. 2,390,408 (1945). G. H. Young (Stoner-Mudge Inc.), *Antifouling Composition.* Al powder is used as a pigment in antifouling compositions, used on seaplane hulls and pontoons.

(6183) U. S. 2,400,029; 2,400,057 (1946). A. A. Somerville (R. T. Vanderbilt Co.), *Vulcanization of Synthetic Rubber.* Metallic Cu is used as an additive or a vulcanization accelerator in producing synthetic rubber.

(6184) U. S. 2,400,544 (1946). B. L. Kline and C. E. Mobius (Western Union Telegraph Co.), *Conductive Paper.* Powdered metal in diglycol stearate is impregnated on a paper web to form the conductive base of an electrosensitive recording blank.

(6185) U. S. 2,400,576 (1946). F. J. Sigmund and W. S. Hlavin (Sigmund Corp.), *Deposition of Rubber.* Zn powder is used to coat resin covered coil heads in a process of depositing rubber on magnetic cores.

(6186) U. S. 2,402,528 (1946). M. Bean, *Pattern Mold.* Bronzing powder is used for dusting the face of a pattern mold.

(6187) Brit. 590,388 (1947). C. F. Styles, *Producing a Compounded Article by Molding Process.* A pressed and heated mixture of Al alloy powder, urea- or phenolformaldehyde-resins, textile fiber and asbestos has useful physical properties.

(6188) Brit. 592,633 (1947). English Metal Powder Co. Ltd., H. Meyersberg, W. G. Wearmouth, *Metal-Containing Cellulose-Acetate Films.* Mottled patterns in cast cellulose acetate films are obtained by incorporating 4-8% of a mixture of leafing and non-leafing Al powder in acetate, pouring mixture into 10 times its weight of acetone, and casting.

(6189) U. S. 2,415,887 (1947). J. F. Joy, *Journal Seal.* A compound of oil resisting synthetic rubber with powdered anti-friction metals, *e.g.* bronze or brass, is substituted for a portion of C commonly used in such synthetics.

(6190) U. S. 2,422,046 (1947). S. Ruben, *Electrode for Alkaline Dry Cells.* The electrode comprises a sprayed layer of Zn on a paper strip; one edge of the paper is protected to leave an uncoated margin.

(6191) U. S. 2,427,383 (1947). J. W. Bryce (International Business Machines Corp.), *Statistical Machine Controlled by Magnetic Frequency Coded Records.* The device employs record cards of paper impregnated with granular magnetic material, *e.g.* Fe filings, or metal powder in the paper pulp, or a foil of magnetic material between two layers of paper.

(6192) U. S. 2,429,698 (1947). W. K. Schneider (Stoner-Mudge Inc.), *Producing Polysulfide Rubber Coatings.* A gasoline-resistant coating of an organic polymer and an accelerator consisting of oxides and peroxides of Cu, Mn, Mg, and Zn is made by mixing the ingredients and then exposing the liquid coating to the action of a promotor.

(6193) U. S. 2,429,986 (1947). E. C. Bowers (Minnesota Mining & Mfg. Co.), *Transferable Silk Screen Stencil.* A stencil film for hand-cutting stencil designs on paper sheet is backed with a water soluble adhesive coating, a second film of cellulose nitrate lacquer and a roughening agent of whiting, pumice powder and Mg powder.

(6194) Brit. Appl. 5779/48 (1948). Crane Packing Ltd., *Anti-Friction Material.* An anti-friction material for use as sealing washers or bearings is obtained by mixing 27.8% of a powdered alloy, composed of 84% Pb, 12% Sb, 4% Sn, with 22.4% asbestos float, 35% thermosetting resin, 14.1% graphite and 0.5% Zn stearate.

(6195) U. S. 2,444,034 (1948). N. H. Collings and R. J. H. Beverton (Standard Telephone & Cables Ltd.), *Electrically Conducting Adhesive.* The adhesive is composed of 36% powdered Ag, 23% cellulose acetate, 41% benzyl alcohol.

(6196) U. S. 2,447,379 (1948). F. R. Wenger (Focal Co.), *Metallizing Non-Metallic Articles.* The process comprises subjecting the article made of organic matter to a bath of alcohol, acetone and $AgNO_3$, drying, and subjecting to a bath containing an alkali metal hydroxide and then to a reducing bath of $NaHSO_3$ and Zn.

(6197) Brit. 615,211 (1949). M. M. P. R. De La Fournière, *Manufacturing Hollow Metallic Bodies.* Aircraft wings, fuselage or propellor blades are made by spraying metal upon collapsible wooden patterns.

(6198) Brit. 625,413 (1949). J. Marney, *Sprayed Metal Wireless Aerial.* The aerial is manufactured by spraying a film of metal onto a shot-blasted section of the fusilage of non-conducting material, *e.g.* wood.

(6199) U. S. 2,458,877 (1949). W. D. Rose (Standard Oil Development Co.) *Photographic Developing Method and Apparatus.* A light sensitive paper may be impregnated with Cu or other suitable metal powder.

(6200) U. S. 2,459,408 (1949). J. A. Bicknell (S. D. Warren Co.), *Aqueous Aluminum-Casein Coating Composition.* A decorative and useful coating for paper is prepared by combining casein with finely divided Al.

(6201) U. S. 2,459,896; 2,459,897 (1949). G. Schwarz, *Silver Impregnation.* A relatively permanent deposit of yellow highly dispersed colloidal Ag, applicable to antiseptic bandages, or germicidal filtration of drinking water, is produced on organic fibers by reducing an aqueous solution containing Ag ions in contact with the organic fibers; the solution is reacted with sufficient alkylolamine to effect such reduction.

(6202) U. S. 2,461,201 (1949). R. P. Ellis, *Flexible and/or Elastic Self-Locking Band.* A filling of 10-60% magnetizable powder is added to rubber while it is still in a liquid condition; the article can then be held in adjustable closed relation by merely bringing the permanently magnetized serrated ends of the article together.

(6203) U. S. 2,466,311 (1949). W. C. Hall, *Apparatus for Preventing Radio Interference.* The invention deals with the prevention of electrical discharge from certain conductive surfaces of aircraft. Such surfaces may be coated with non-conductive fibrous material having projecting fibers coated with fine metal particles.

(6204) U. S. 2,471,607 (1949). F. G. Calkin (Finch Tele-Gommunications, Inc.), *Facsimile Recording Papers.* An electrically discolorable coating for the dry conductive facsimile recording paper consists of 1.875 parts Pb formate, 5.0 parts TiO_2, 0.31 parts Zn, 10 parts polyvinyl acetate solution and 20 parts ethyl acetate. Formates of Cu, Ni, Cd, and Bi react in much the same manner as the Pb formate.

(6205) U. S. 2,479,868; 2,479,869 (1949). P. F. Rossmann, *Sound Motion-Picture Film.* Powdered Ni-Co mixed with a suitable binder is used in a magnetic sound track, or powdered or finely-divided magnetic material is coated on Scotch tape.

iv. Paints, Pigments, and Inks

(6206) U. S. 18,338 (1857). H. Hoffman, *Improvements in Bronzing Liquids.* A fluid bronze composition is formed by combining metallic powder with collodion and used to coat objects for decoration and preservation.

(6207) U. S. 298,941 (1884). L. Brown, *Paint.* A paint is made of sublimated Zn powder and whiting.

(6208) U. S. 512,224 (1894). J. Sachs and A. Mueller-Jacobs, *Mineral Colors.* Mineral colors for use as a substitute for bronze paints comprise powdered animalized mineral including bronze powder dyed with an organic dye.

(6209) U. S. 546,888 (1895). P. Inch, *Paint.* The paint consists of granular Sn and Zn, oil, and drier.

(6210) U. S. 613,944 (1898). A. Schwenterley (National Water Bronze Co.), *Coloring Composition.* The material is produced from powdered material including bronze powder and a binder.

(6211) U. S. 642,358 (1900). L. Ott and H. Riffelmacher (Bronzefarbenwerke, A. G. and H. Riffelmacher), *Paint.* Al powder, produced by pouring fluid Al into water and comminuting the particles, is used for a paint after mixing with a suitable vehicle.

(6212) U. S. 701,718 (1902). C. M. Hall, *Paint.* A paint pigment consists of finely pulverized metallic alloy containing Fe and an electropositive element mixed with oil.

(6213) German 147,013 (1903). Bronzefarbenwerke, A. G., *Method of Producing Leafings of Metal.* Leafings and flakes of metal, suitable for use as paints, are produced by pouring out the metal on the inner wall of a hollow cooled cylinder.

(6214) U. S. 800,017 (1905). G. P. Reuhl, *Process of Finishing Moldings.* A process of finishing moldings comprises applying a mixture of powdered bronze fluxed with suitable liquid carrying, adhering and protecting media.

(6215) U. S. 846,585 (1907). C. A. Ludewig, *Method of Producing Bronze Printings.* Bronze powder is mixed with a soluble powdered carrier applied over a solvent which renders the carrier transparent.

(6216) German 197,094 (1908). J. D. Miederer, *Bronze Colors.* Bronze colors are produced through impact of falling molten metal on a rotating cone, which acts as a buffer.

(6217) U. S. 1,110,358 (1914). F. Sternberg, *Paint Composition.* The paint comprises a mixture of powdered ingredients including Cu and anilin.

(6218) Brit. 226,286 (1924). W. P. Heskett, *Metal Powders for Use in Paints.* Metallic powder for paints is produced by forming an alloy of the constituents and mechanically pulverizing it prior to its self-disintegration.

(6219) Brit. 227,023 (1925). F. Caspari, *Metallic Paints.* A process for the manufacture of a protective paint consists of mixing impalpable metallic dust with a paint-carrying drying oil while preventing admission of air.

(6220) Brit. 259,483 (1926). W. Bradley and W. H. J. Rattew, *Bronzing and Similar Coating Compositions.* The compositions are made from metallic powders by mixing them with a mixture of resin, oil and celluloid.

(6221) U. S. 1,600,156 (1926). W. Whyte, *Decorative Painting.* A paint is claimed which separates into relief designs on non-absorbent wall surfaces, over which may be applied Au or bronze powder.

(6222) U. S. 1,717,140 (1929). O. Brandenberger, *Lead Paint.* The paint comprises Pb powder, powdered metals adapted to prevent oxidation, and a binder.

(6223) U. S. 1,756,772 (1930). L. Weisberg and R. B. Stevens (Alchemic Gold Co.), *Method of Coating Powders.* Bronze powders or other metallic pigments are coated with lacquers or the like.

(6224) U. S. 1,795,962 (1931). C. Nittinger, *Rust-Resisting Paint.* The paint comprises powdered coal slag, electropositive Zn and a binder.

(6225) Brit. 385,310 (1932). F. Rahtjen and M. Ragg, *Anticorrosive Paint.* A mixture of 50% basic Pb antimonate and 50% Pb-Sb alloy is ground to a paint with a binder.

(6226) Brit. 391,148 (1933). S. R. Sheppard, *Pigments.* Al powder is used to take up a dye suitable for the production of a lake.

(6227) Brit. 391,839 (1933). Metals Disintegrating Co., *Bronze Powders.* A stable paste consists of a flaked metal suspended in liquid which is compatible with the common varnish vehicles.

(6228) German 579,196 (1933). F. Mitterberger, *Production of Weatherproof Paint.* A bituminous solution mixed with Al-bronze and turpentine may be sprayed.

(6229) U. S. 1,915,201 (1933). A. F. M. Ragg, *Producing Paints Containing Metal Powders.* The production of metal-containing pigments comprises atomizing molten metal and projecting it against finely distributed solid ingredients adapted for anti-corrosive paints.

(6230) U. S. 1,920,234 (1933). F. C. Arthur (Aluminum Co. of America), *Aluminum Bronze Powder for Paints.* Al is worked to thin flake-like particles and lubricated with ricinoleic acid.

(6231) U. S. 1,937,575 (1933). R. M. Joyce, *Latent Print Lifting Means.* An impression is first lightly dusted with Al powder, and the excess is blown away; the remaining particles of the pigment adhere to the oil which makes up the print and they serve to clarify it.

(6232) U. S. 1,951,203 (1934). H. E. Pitman and S. Silk, *Transferring Impressions of Fingerprints.* Metal powder is applied to the finger prints with an atomizer, so that the characteristic lines stand out.

(6233) U. S. 1,954,462 (1934). U. C. Tainton, *Zinc Powder for Use in Paints.* Zn powder is manufactured by producing a Zn foil and subjecting the pieces of the foil to a wet grinding operation, then withdrawing the resultant liquid for a classification.

(6234) Brit. 431,641 (1935). E. Wurbs, *Anti-Rust and Rust-Removing Paint.* 40 parts white Pb, 20 parts Pb powder, 12 parts Fe powder, 4 parts K_2CO_3 are mixed with 100 parts varnish.

(6235) Brit. 436,164 (1935). New Jersey Zinc Co., *Zinc Dust Paint. Cf.:* U. S. 2,044,292 (No. 6240).

(6236) Canadian 354,050 (1935). H. H. Mandle, *Metal Comminuting Process.* Al flakes, for use as a paint ingredient, are mixed in the paste condition with hydrocarbons of high purity and a small portion of an ester of high molecular aliphatic acid.

(6237) U. S. 2,002,891 (1935). E. J. Hall (Metals Disintegrating Co.), *Aluminum Powder Paste Process.* Al bronze powder, for use in paints, is produced by subjecting the powder to the action of a leafing agent dissolved in a volatile paint thinner to form a sludge with the metal, then removing excess liquid to form a paste.

(6238) U. S. 2,017,850 (1935). D. M. Boothman (Aluminum Co. of America), *Aluminum-Bronze Powder for Paint.* The powder is produced by coating thin flat Al particles with lard oil or a fatty acid preventing the welding of overlapping pieces under pressure, then thinning the coated metal by a rolling pressure to break up the metal and continuing the rolling to break up the metal into flakes.

(6239) U. S. 2,038,850 (1936). J. A. Murphy, *Recovery of Metal Values and Use for Paints.* A shiny, oxide-free Cu powder is precipitated from a deoxidized solution of metal bearing material in the absence of free O_2; the powder is mixed with a paint vehicle.

(6240) U. S. 2,044,292 (1936). L. D. Grady, Jr. (New Jersey Zinc Co.), *Zinc Dust Paints.* A Zn dust oil paint contains a small amount of a water absorbent substance of CaO, BaO and bauxite.

(6241) Brit. 477,451 (1937). Metals Disintegrating Co., Inc., *Metallic Pigment Pastes.* Pigment pastes containing leafing metal particles and a thinner or solvent have added to them an amount of the leafing agent in addition to that provided in the normal leafing process. For example, 1% free stearic acid is mixed with Al paste.

(6242) U. S. S. R. 51,089 (1937). B. V. Troitskii, A. A. Gelrikh and I. L. Andreevskii, *Bronze Powder from Mica Waste.* H_2SO_4 is added to mica waste and heated to 700° C. (1290° F.) to yield a bronze powder pigment.

(6243) U. S. 2,068,966 (1937). R. R. Thurston and R. J. Ruble (The Texas Co.), *Metallic Paint.* A metallic paint consists of 12-18 parts of metal powder, 15-25 parts of asphalt emulsion, 15-60 parts of a solvent for bitumen and 30 parts of water.

(6244) U. S. 2,071,156 (1937). M. Baer (H. M. Baer), *Coloring Bronze Powders.* An Al bronze powder is dyed in the presence of a water soluble inert organic solvent.

(6245) U. S. 2,080,346 (1937). U. C. Tainton (Tainton Research Co.), *Metallic Powder.* Metallic powder suitable as a pigment consists of Zn in flake form having smooth, bright surfaces.

(6246) Brit. 489,574 (1938). Imperial Chemical Industries Ltd., J. A. Rodley, and F. Hill, *Coloring Aluminum Powder.* A process for coloration of Al powder consists of treating it with a hot aqueous solution of hetropoly-acid derived from W and thereafter applying a basic dyestuff.

(6247) Canadian 374,192 (1938). Acme White Lead & Color Works and J. F. Hofmann, *Non-Leafing Bronze Powder Coating Composition.* A coating composition consists of resin varnish with a highly volatile solvent and a fine non-leafing bronze powder.

(6248) U. S. 2,106,228 (1938). O. Schober (American Lurgi Corp.), *Coloring and Protective Coating.* The coating comprises powdered Al and Si in a liquid binding medium, such as boiled linseed oil.

(6249) U. S. 2,112,497 (1938). E. Kramer (Hartstoff Metall A. G.), *Plant for the Manufacture of Bronze Colors.* The apparatus consists of a comminuting machine, a machine for polishing metal particles, a conduit between machines and means for supplying O_2 in regulated amounts.

(6250) U. S. 2,113,449 (1938). C. W. Hoffman (Pratt & Lambert Inc.), *Surface Paint.* A multitoned metallic effect is produced by projecting against the surface droplets of paints having metal powder suspended therein.

(6251) German 681,884 (1939). Metals Disintegrating Co., *Bronze Pastes and Powders.* Al bronze powder is milled to leafs in presence of O_2 and a flotation medium, *e.g.* stearic acid in alcohol.

(6252) U. S. 2,144,953 (1939). O. A. Ziehl (Metals Disintegrating Co.), *Bronze Pigments.* Bronze pigments consist essentially of metal flakes, a thinner and a leafing agent.

(6253) U. S. 2,168,212 (1939). G. H. Hicks (Acme White Lead & Color Works), *Synthetic Metallic Enamel.* The enamel comprises finely ground bronze powder, a volatile solvent and synthetic resin.

(6254) U. S. 2,176,597 (1939). H. A. Sweeney (National Copper Paint Co.), *Metallic Paint.* A metallic paint contains amorphous Cu.

(6255) U. S. 2,178,018 (1939). J. F. Hofmann (Acme White Lead & Color Works), *Bronze Powder Coating.* The coating is produced by mixing bronze powder with synthetic resin varnish.

(6256) U. S. 2,178,179; 2,178,180; 2,178,181 (1939). E. L. McMahan (Aluminum Co. of America), *Metal Paste Pigment.* The pigment comprises metal flakes with leafing properties stabilized by phenol, naphthol or amines.

(6257) U. S. S. R. 56,305 (1940). S. V. Bogdanov, *Reducing Splitting of Azo Dyes.* The stabilization is accomplished by means of Zn dust activated with Cu in a NaCl solution.

(6258) U. S. S. R. 56,404 (1940). I. N. Sapgir, *Paint Pigment.* Zn dust is mixed with a solution of NaCl or KCl and $CaCl_2$.

(6259) U. S. 2,185,194 (1940). C. P. Harris, *Compressed Metal Powder Aggregates Suitable for Use as Pigments.* Polished metallic powders are treated with an amount of liquid so small that there is no sensible moistening of the powder, then the mass is slowly compressed into a briquette.

(6260) U. S. 2,193,663 (1940). F. C. Arthur (Aluminum Co. of America), *Aluminum Bronze Powder for Paints.* The manufacturing process comprises flaking Al with leafing agent and volatile liquid, removing the volatile liquid and brushing the dried flakes.

(6261) U. S. 2,213,644 (1940). L. C. Antrim (Autographic Register Co.), *Method of Coating.* In the making of a transfer device for repeated manifolding use, metal powder is mixed in the inking solution.

(6262) U. S. 2,226,150 (1940). R. C. Alborn (Eastman Kodak Co.), *Heat Resisting Paint.* The paint comprises an asphalt, oil-resin varnish, bronze powder and an extending pigment.

(6263) U. S. 2,234,164 (1941). C. P. Harris (U. S. Metal Powders Inc.), *Metallic Pigment Paste.* The paste is produced from metal powders mixed with a hydrocarbon solvent and a stabilizing agent.

(6264) U. S. 2,245,745 (1941). G. L. Ball, *Metallic Coating.* The coating is of an Al-pigmented alkali-resistant baked type.

(6265) U. S. 2,250,955; 2,250,956 (1941). C. P. Harris (U. S. Metal Powders Inc.), *Metallic Pigment Paste.* The paste is produced by mixing metal powder with ethyl butyrate solvent or camphor.

(6266) U. S. 2,257,595 (1941). E. W. Danielson, *Paint.* A paint for simulating wood grain comprises nonleafing metal powder in flake form, coloring ingredients and binder.

(6267) U. S. 2,272,629 (1942). F. C. Arthur (Aluminum Co. of America), *Metallic Pigments.* Metallic pigments in dry powder form are produced by heating a sludge of metallic powder and a volatile liquid and subjecting it to the action of impact bodies.

(6268) U. S. 2,273,597 (1942). A. Schroeder (Pure Oil Co.), *Pigments.* Finely divided pigments having a metallic lustre are produced by decomposition of metal salts of organic acids.

(6269) U. S. 2,274,766 (1942). O. A. Ziehl (Metals Disintegrating Co.), *Bronze Pigments.* The pigments are manufactured by wet-milling bronze pigments mixed with a liquid hydrocarbon solvent and a leafing agent.

(6270) U. S. 2,299,034 (1942). R. S. Reynolds (Reynolds Metals Co.), *Metallic Flakes.* Flakes suitable for use as pigments are formed by disintegrating composite metal foils.

(6271) U. S. 2,302,305 (1942). S. W. Farrell, *Gloss Enamel.* Gloss enamel or pigmented lacquer contains Al or other flake material.

(6272) U. S. 2,302,332 (1942). R. M. Leekley (E. I. du Pont de Nemours & Co.), *Decorative Coating.* A decorative coating composition has incorporated in it powdered metals in polyhexamethylene adipamide dispersed in a liquid medium.

(6273) French 881,984 (1943). Titan Co. A. S., *Production of Pigments of Titanium.* Small quantities of Cb or Ta are added to the solution of TiO_2 before the hydrolysis, to facilitate concentration.

(6274) U. S. 2,309,377 (1943). G. M. Babcock (Reynolds Metals Co.), *Nonleafing Aluminum Paste.* A nonleafing Al paste comprises a thinner and a deleafing agent for Al powder.

(6275) U. S. 2,312,088 (1943). C. S. Fleming, *Bronze Powder for Paints.* Bronze powder is improved by incorporating a composition which improves the stability of leafing properties.

(6276) U. S. 2,323,982 (1943). E. J. Dunn (National Lead Co.), *White Lead.* A process for producing white lead employs a mixture of PbO and powdered Pb.

(6277) U. S. 2,326,157 (1943). A. T. McCord (Sherwin-Williams Co.), *Activated Anhydrite.* $CaSO_4$ is used as an extender pigment in paints incorporating Zn dust.

(6278) U. S. 2,328,465 (1943). G. Kopp, *Dyestuff.* Powdered metals are used as agents in a dyestuff.

(6279) U. S. 2,330,291 (1943). J. E. Kirby (E. I. du Pont de Nemours & Co.), *Azo Dye.* In the production of an azo dye, Zn dust is used to reduce an intermediate.

(6280) U. S. 2,340,280; 2,345,955 (1944). H. L. Wampner (Commercial Solvents Corp.), *Coating Composition.* A coating composition having a reduced tendency to gel or agglomerate comprises bronze powder, cellulose nitrate and a neutral salt of malic acid.

(6281) U. S. 2,349,571 (1944). C. F. Cummins (Dow Chemical Co.), *Lacquer Composition.* The composition contains Al or bronze powder, and is capable of retaining powder suspended in leaf form on storage.

(6282) U. S. 2,353,058 (1944). L. J. Mitchell, *Bronze Paste.* The paste consists of straight-run bronze powder resin and a volatile thinner free of S and acidity.

(6283) U. S. 2,355,639 (1944). M. A. Ferst and C. F. Wysong (M. A. Ferst Ltd.), *Pencil Lead.* The composition has incorporated in it metal powders or metallic salts reducible to free the metal under firing.

(6284) U. S. 2,368,767 (1945). M. C. Moore (Hercules Powder Co.), *Adhesive Composition.* An adhesive composition is used in pigmented or abrasive coating compositions to provide binding action on the pigments or abrasives, *e.g.* metal dusts.

(6285) U. S. 2,372,334 (1945). D. Murphy (Chadeloid Chemical Co.), *Lacquer Coating.* The coating consists of Al bronze in pigmented cellulose-ester as a binder.

(6286) U. S. 2,379,019 (1945). A. T. McCord and H. F. Saunders (Sherwin-Williams Co.), *Pigment Material.* Finely divided Zn is used as a pigment.

(6287) U. S. 2,380,456 (1945). C. E. Maier, S. L. Flugge and E. C. Pfeffer (Continental Can Co. Inc.), *Pigmented Lacquer.* Al powder is added to the lacquer.

(6288) U. S. 2,384,493 (1945). C. J. Rolle (Interchemical Corp.), *Bronzing Lacquer.* Al bronze powder in a lacquer vehicle is used to coat metal prior to carbonizing to produce black surfaces for radio tube plates.

(6289) U. S. 2,385,125 (1945). G. R. Barrett (Monsanto Chemical Corp.), *Nitrocellulose Lacquer Compositions.* Malonic acid is added to nitrocellulose compositions pigmented with metal powders, such as bronze, Al-bronze, or Au-bronze to inhibit gel formation.

(6290) U. S. 2,387,243 (1945). W. W. Castor, *Protective Coating.* Fe powder is plated with Au and dispersed in a lacquer to give an Au coating paint.

(6291) U. S. 2,388,318 (1945). C. J. Frosch (Bell Telephone Laboratories), *Polyesters.* Metal powder is added to a molding and coating compound.

(6292) U. S. 2,388,600; 2,388,601; 2,388,602 (1945). H. M. Collins (Shawigan Chemicals Ltd.), *Polymerization of Esters.* Resins are used as vehicles for carrying metal powders for coatings.

(6293) Brit. 578,887 (1946). A. K. Balch, *Aluminum Powder.* The effect of fluorescent coatings on building walls is improved by applying an under-coating of Al powder with a binder.

(6294) U. S. 2,392,135 (1946). H. O. Farr (Pittsburgh Plate Glass Co.), *Printing Ink.* Al powder is used as a pigment in ink compositions.

(6295) U. S. 2,393,731 (1946). G. M. Babcock (Reynolds Metals Co.), *Non-Leafing Aluminum Paste.* Al pigment, in the form of a non-leafing Al paste, is produced from a normally-leafing Al powder, while retaining the shape and size of the Al particles.

(6296) U. S. 2,400,447 (1946). F. H. Wells and J. J. Root (American Machine & Foundry Co.), *Web Registering Devices.* Fe powder is used in a printing ink on a wrapper, to act as a magnet for controlling the web registering devices.

(6297) U. S. 2,405,249 (1946). M. Wilson (Fred'k H. Levey Co. Inc.), *Coating Films.* Powdered metal is used to eliminate solvents from coating films by exposing the films to the effect of an alternating electrostatic field.

(6298) French 920,337 (1947). Tréfileries et Laminoires Du Havre, *Manufacture of Aluminum Powder for Use in Paints, Inks, etc* A special Al flake powder is claimed to have a covering power 4-5 times greater than that of similar powders.

(6299) U. S. 2,418,450 (1947). L. Auer (Interchemical Corp.), *Flatting Agent.* The agent consists of a soap of rosin and a metal, *e.g.* alkali earth, Mg, Zn, or Al in pigment particle size.

(6300) U. S. 2,418,479 (1947). B. C. Pratt and P. L. Salzberg (E. I. du Pont de Nemours & Co.), *Process for Orienting Ferromagnetic Flakes in Paint Films.* The process comprises subjecting a wet paint film containing the ferromagnetic flake to a magnetic field; the directional angle between the film and the field varies from parallel to perpendicular at short intervals of time.

(6301) U. S. 2,424,256 (1947). W. A. Schmidt and J. A. Sprung (General Aniline & Film Corp.), *Color Developers.* In the process for the production of azo-dyestuff images in an exposed Ag halide emulsion layer, consisting of applying a solution of an aromatic sulfonhydrazide in the presence of an azo dye coupling element; Zn dust is used as a reactant.

(6302) U. S. 2,432,465 (1947). G. M. Babcock (Reynolds Metals Co.), *Method of Making Metallic Pigments.* Sn-coated Pb foil or Al-coated Zn foil is milled with 2-5% Al and 1% higher fatty acid; the pH is kept to 7.4 during milling by adding $Al_2(SO_4)_3$.

(6303) U. S. S. R. 69,883 (1947). B. P. Golubev, *Imparting Bronze Color to Aluminum Powder.* Al powder is treated with a hot solution of Cr_2O_3 and then with $KMnO_4$ solution to attain the desired hue.

(6304) Brit. 606,565 (1948). Reynolds Metals Co., *Manufacture of Pigments.* Aluminum dross is crushed and ball-milled in mineral spirits containing 3% Al-naphthenate as thickener; the resulting slurry is thinned with mineral spirits and the product screened.

(6305) Brit. 609,760 (1948). Metals Disintegrating Co. Inc., *Paint Composition.* An Ag paint for electrically conducting coatings on ceramics is prepared from Ag flakes treated with HCl solution.

(6306) Swiss 249,124 (1948). Sandoz Ltd., *Aluminum Powder for Coloring.* Al powder is treated with solution of alkali and active halogen, filtered and colored.

(6307) U. S. 2,433,833 (1948). L. Auer, *Flatting Agent.* A coating composition drying to a transparent dull or flat surface contains a glossy drying non-aqueous organic film which is made by forming a vehicle with a soap of metals, such as Al, Zn, Mg in pigment size particles.

(6308) U. S. 2,455,854 (1948). G. E. Conde (E. I. du Pont de Nemours & Co.), *Strippable Coating Composition.* The composition comprises 100 parts of an uncured chlorophene polymer, obtained in the presence of S, 15-50 parts Al powder, and a liquid volatile vehicle.

(6309) U. S. 2,456,313 (1948). B. C. Pratt (E. I. du Pont de Nemours & Co.), *Pigment Composition.* A mixture of discrete particles of a non-magnetic flake metal, such as Al, is combined with 10-25% ferromagnetic pigments; all flakes are susceptible to a magnetic orientation, when contained in an undried film.

(6310) Brit. 621,566 (1949). Imperial Chemical Industries Ltd., *Pigment Composition.* A film containing Al pigment with improved corrosion resistance is prepared by coating Al flakes with polyethylene.

(6311) Brit. 622,978 (1949). E. I. du Pont de Nemours & Co., *Coating Composition.* Color-stable black and gray finishes are made from pigmented enamels containing hydrous Fe_3O_4 alone or diluted with a solution containing Al powder.

(6312) Brit. Appl. 19503/49; 19506/49 (1949). Aluminum Co. of America, *Treating of Metallic Pigments.* Al paste is treated in a water-cooled edge-runner mill to improve the consistency and increase the fineness of the pigments. The reflectivity and stability of the paste can be improved by adding 1-4% solid stearic acid.

(6313) Brit. Appl. 19504/49 (1949). Aluminum Co. of America, *Water-Emulsifiable Paste Pigments.* The pigments are composed of 52.3% Al flake, 13.3% mineral spirits, 1% stearic acid, 6.6% casein, 23.4% tall oil, 2.65% Na_2CO_3, 0.6% anhydrous $Na_2B_4O_7$, 0.05% $Na_2Si_2O_5$ and 0.1% Na stearate.

(6314) U. S. 2,461,352 (1949). V. R. Smith and D. E. Stevens (California Research Corp.), *Water-In-Oil Emulsion Paints Containing a Leafing Pigment.* The products comprise a vehicle, a leafing pigment, such as powdered Cu, Al or Cr and water dispersed in the vehicle with or without an emulsifying agent.

(6315) U. S. 2,462,631 (1949). L. D. Gittings (Monsanto Chemical Co.), *Coating Compositions.* Al paint may be coated over bituminous paints and can be used as a coating for concrete, creosoted wood, stacks in chemical plants, etc.; black, metallic pigments, and other pigments are used in the composition.

(6316) U. S. 2,462,728 (1949). J. H. Debs (Chicago Metallic Mfg. Co.), *Tin Coated Baking Pan With Painted Exterior Surfaces.* A coating of heat absorbing paint, containing Al powder, is applied on the exterior surfaces of a sheet metal Sn-coated baking pan. The paint is non-permanent in character under the conditions of heat and wear and serves gradually to expose the Sn surface during burning out of the surface.

(6317) U. S. 2,466,770 (1949). R. T. Hucks (E. I. du Pont de Nemours & Co.), *A Stable Coating Composition and a Process of Making It.* Durable black and gray finishes of striking appearance and transparency are obtainable according to this process. Metallic powders, such as Al, Ni, etc., are useful for obtaining the transparent effect.

(6318) U. S. 2,468,920 (1949). A. R. Brown (E. I. du Pont de Nemours & Co.), *Hammered Metal Finish Composition.* The composition contains about 28 parts of ordinary cellulose nitrate to about 1 part of dynamite type cellulose nitrate, and about 1.5-7.5% finely divided metal powder based on the weight of the total solids in the composition; Al, Ni, bronze and other powders are used.

(6319) U. S. 2,472,680 (1949). B. C. Pratt (E. I. du Pont de Nemours & Co.), *Process of Making Coating Compositions Using Polyethylene Coated Pigments.* To obtain discrete pigment particles coated with a film of solid polymer consisting of polymerized ethylene, finely divided metallic particles (Al flakes, steel, Cu, bronze, Zn, etc.) are stirred in a hot organic solution of the polymer, the mixture is cooled and the solvent is removed from the coated metallic particles.

(6320) U. S. 2,476,178 (1949). O. J. Cahill (A. E. Braun), *Coating Compound.* Al flakes are incorporated and dispersed in a mix of 100 parts of a mixture of asphalt varnish and asphalt gilsonite varnish, approximately 6¼ parts of drying and semi-drying oils, and 50 parts of asbestos fiber, in the proportion of from 1 to 1½ pounds per gallon of mix.

v. Miscellaneous Applications (e.g., Drugs, Photographic Reagents, etc.)

(6321) Brit. 13,756/1910 (1911). R. H. A. Plimmer, *Therapeutic Substance.* Finely divided pure Sb is produced by electrolysis of $SbCl_3$ in HCl.

(6322) U. S. 2,295,074 (1942). E. C. Britton and J. G. Eisenman (Dow Chemical Co.), *Phenothiazine.* For use as an insecticide, phenothiazine is purified by treating it with metal powders.

(6323) U. S. 2,325,790; 2,325,791 (1943). W. Moore and R. O. Roblin (American Cyanamid Co.), *Diallyl Maleate.* Diallyl maleate is incorporated with bronze powder for use as an insecticide.

(6324) U. S. 2,344,895 (1944). G. W. Pearce and A. W. Avens, *Insecticide.* A mixture of powdered Ca arsenate and Zn is heated to produce Zn-Ca arsenate.

(6325) U. S. 2,368,565 (1945). G. W. Pearce and A. W. Avens, *Zinc Calcium Arsenate.* The production comprises mixing dicalcium arsenate with powdered Zn or ZnO in excess and heat treating the mixture.

(6326) U. S. 2,385,636 (1945). W. R. McLain, *Insecticide.* Powdered Al is mixed with As_2O_3.

(6327) U. S. 2,395,266 (1946). H. A. Gardner, *Float.* Al powder is used to fill floats for boat or aircraft hull or wings.

(6328) U. S. 2,395,454 (1946). H. A. Bruson, *Insecticide.* Cu powder is used in a toxicant.

(6329) U. S. 2,411,202 (1946). H. A. Gardner, *Filled Float.* Al powder is used as one reactant in filling a float; a rigid porous metallic sponge is formed by reacting Al with an acidic resin in the float casing.

(6330) U. S. 2,439,538 (1948). C. J. Burgess, *Deodorizing Composition for Food Storage Compartments.* Vermiculite and Al powder is used to produce a porous unit, in combination with activated C, CaC_2 and cement.

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